

# Anatomy of the ostia venae hepaticae and the retrohepatic segment of the inferior vena cava

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## ABSTRACT

In 30 normal adult livers the retrohepatic segment of inferior vena cava had a length of 6.7 cm and was totally encircled by liver substance in 30% of cases. Altogether 442 ostia venae hepaticae were found, averaging 14.7 per liver and classified as large, medium, small and minimum. The localisation of the openings was studied according to the division of the wall of the retrohepatic segment of the inferior vena cava into 16 areas.

*Key words:* Vasculature; hepatic veins; inferior vena cava; liver.

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## INTRODUCTION

Knowledge concerning the openings of the hepatic veins into the retrohepatic segment of the inferior vena cava (IVC) is important for several reasons. Gibson (1959) reported that the openings of the hepatic veins are important in the control of the hepatic circulation because of their sphincteric mechanism. In surgery, knowledge about these openings is relevant in the treatment of hepatic trauma with hepatic vein avulsion and also in the resection of parts of diseased livers (Kennedy & Madding, 1977; Nakamura & Tsuzuki, 1981). Due to an increase in the frequency of treatment of traumatic or neoplastic injuries by resection of hepatic segments, Goldsmith & Woodburne (1957) emphasised the importance of detailed knowledge about these openings. Heloury et al. (1988), in a study of the caudate lobe, confirmed the opinion of other authors about the anatomical study of the liver, and reported that this knowledge is of significance for the Budd–Chiari syndrome, when anastomoses of the hepatic veins are considerably developed but their calibre remains inadequate to drain all the venous blood from the liver, with consequent major hypertrophy of the caudate lobe.

In the relevant literature, the study by Chang et al. (1989) is the most complete about hepatic venous drainage and the retrohepatic segment of the inferior vena cava (IVC), and has proposed a classification of the openings on the basis of diameter and localisation.

Based on the study by Chang et al., we examined the retrohepatic segment of the IVC and classified the openings, considering localisation and calibre.

## MATERIALS AND METHODS

Thirty livers from adult cadavers, without hepatic pathology, were used for the study. They were obtained at necropsies, fixed in 10% formalin and in 5% formalin. The evaluation of the retrohepatic segment of the inferior vena cava (IVC) included the determination of the axial direction, length measurement, and measurement of the anteroposterior and transverse diameters of the superior opening and of the extent of exposure of its posterior wall. When the segment was partly or totally encircled by hepatic substance, the height and thickness of that substance were also measured.

The posterior wall of the IVC was then cut longitudinally and the hepatic vein openings were measured. The openings, mostly oval in shape, were classified according to their widest diameter and localisation. On the basis of measurement of the widest diameter, the openings were classified as large (LO) when the widest diameter was more than 1.0 cm, medium (MO) when it was 0.5–1.0 cm, small (SO) when it was 0.3–0.5 cm and minimum when the widest diameter was less than 0.3 cm. To classify the openings according to localisation as proposed by Chang et al. (1989), the internal wall of the retrohepatic segment of

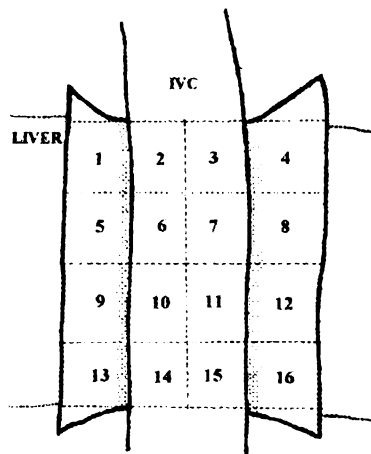


Fig. 1. Division of the IVC retrohepatic segment into 16 areas.

the IVC was divided into 16 areas, comprising 4 rows and 4 columns. Figure 1 shows how this segment was divided. Finally, to determine the corresponding hepatic drainage area, probes were inserted into openings whose widest diameter was more than 0.3 cm.

The large openings were divided into superior and inferior according to their localisation. The superior openings (SLO) were located in the first row of the 16 areas and the inferior openings (ILO) in the other 3 rows. Considering the kind of opening and the corresponding drainage vein, the SLO were subdivided into 4 types: single opening when they only received a single draining vein, and double, triple and quadruple openings, when the openings had 2, 3 or 4 draining veins, respectively.

## RESULTS

### *Retrohepatic segment of IVC*

The average length of the retrohepatic segment was 6.7 cm, the range being 10.9–3.5 cm. The axial direction of the IVC was oblique in 22/30 cases (73.3%), vertical in 4/30 cases (13.3%) and curved towards the left in 4/30 cases (13.3%). The IVC was totally enclosed by liver substance in 9/30 cases (30.0%). The enclosed hepatic substance had an average height of 3.2 cm and an average thickness of 0.7 cm, the highest values being 6.3 and 1.3 cm, respectively. In the cases of partial IVC exposure, the average measurement of the nonenclosed IVC posterior wall was 1.0 cm, the highest value being about 2.3 cm. The average values of the widest and shortest diameters of the IVC superior opening were 5.5 and 1.6 cm, respectively.

Table 1. Distribution of SLO hepatic veins

Hepatic veins	Our results		Chang et al. (1989)	
	Number	%	Number	%
Right hepatic (RHV)	25	48.1	58	46.4
Middle hepatic (MHV)	1	1.9	7	5.6
Left hepatic (LHV)	1	1.9	7	5.6
MHV + LHV	21	40.4	53	42.4
MHV + LHV + RHV	4	7.7	—	—
Total no. of openings	52	—	125	—
Average per liver	1.73	—	2.08	—

Table 2. Opening patterns (SLO)

Combination patterns	Our results		Chang et al. (1989)
	Number	%	(%)
Single opening	27	51.9	1.7
Double opening	16	30.8	88.3
Triple opening	7	13.5	10.0
Quadruple opening	2	3.8	—

### *Hepatic vein openings*

Altogether 442 openings were observed, averaging 14.7 per liver. There were 61/442 large openings (13.8%), 53/442 medium (12.0%), 20/442 small (4.5%) and 308/442 minimum openings (69.7%).

For the large openings, 52/442 (11.8%) were classified as superior (SLO) and 9/442 (2.0%) as inferior (ILO). We observed on average 1.73 SLO and 0.30 ILO per liver. The right hepatic vein was the most common for the SLO in 25/52 cases (48.1%), followed by the double opening between left and middle hepatic veins with 16/52 cases (30.8%). We observed 5 different combinations for the right, left and middle hepatic veins, in SLO, which are presented in Table 1. As to the types of SLO, we observed 27/52 (51.9%) cases of single openings, followed by double openings (16/52, 30.7%), triple openings (7/52, 13.5%) and quadruple openings (2/52, 3.8%). Table 2 shows our results in comparison with those of Chang et al. (1989). Among the ILO, the caudate vein is the most common, with 4/9 cases (44.5%). Table 3 gives the distribution of ILO hepatic veins. Of the 53/442 medium openings, an average of 1.77 per liver, 20/53 were from the right posteroinferior vein (37.7%) and 18/53 from the caudate vein (34.0%). The medium opening veins are listed in Table 4. We found 0.67 small openings per liver. The most frequent was the

Table 3. Distribution of ILO hepatic veins

Hepatic veins	Our results		Chang et al. (1989)	
	Number	%	Number	%
Right posteroinferior RHV	3	33.3	17	53.1
Caudate (CV)	2	22.2	—	—
Right posterosuperior	4	44.5	7	21.9
Right superior	—	—	6	18.8
Right posterolateral	—	—	1	3.1
Total no. of openings	—	—	1	3.1
Average per liver	9	—	32	—
	0.30	—	0.53	—

Table 4. Distribution of medium openings

Hepatic veins	Our results		Chang et al. (1989)	
	Number	%	Number	%
Right posteroinferior	20	37.7	26	26.3
Caudate	18	34.0	46	46.5
Right superior	4	7.5	5	5.1
LHV	3	5.7	—	—
MHV + LHV	3	5.7	—	—
MHV	2	3.8	—	—
RHV	1	1.9	—	—
Caudate + MHV	1	1.9	—	—
Right posterosuperior	1	1.9	15	15.1
Right posterolateral	—	—	6	6.1
Right posterointermediate	—	—	1	1.0
Total no. of openings	53	—	99	—
Average per liver	1.77	—	1.65	—

1	2	3	4
-	-	-	-
5	6	7	8
-	2 (22.22%)	3 (33.34%)	1 (11.11%)
9	10	11	12
1 (11.11%)	1 (11.11%)	-	-
13	14	15	16
-	-	-	1 (11.11%)

Fig. 3. Localisation of ILO.

1	2	3	4
5 (9.44%)	4 (7.54%)	1 (1.88%)	2 (3.77%)
5	6	7	8
3 (5.67%)	3 (5.67%)	2 (3.77%)	3 (5.67%)
9	10	11	12
1 (1.88%)	11 (20.75%)	3 (5.67%)	1 (1.88%)
13	14	15	16
-	2 (3.77%)	7 (13.20%)	5 (9.44%)

Fig. 4. Localisation of medium openings.

1	2	3	4
18 (34.62%)	12 (23.07%)	17 (32.69%)	5 (9.62%)
5	6	7	8
-	-	-	-
9	10	11	12
-	-	-	-
13	14	15	16
-	-	-	-

Fig. 2. Localisation of SLO.

right posteroinferior vein, with 11/20 openings (55.0%). The caudate vein followed with 4/20 cases (20.0%) and the right superior vein with 3/20 cases (15.0%). We were unable to identify the vein in 2/20 (10%) of the small openings. Minimum openings occurred in 308/442 cases (69.7%) with an average of

1	2	3	4
-	-	-	1 (5.00%)
5	6	7	8
1 (5.00%)	1 (5.00%)	-	2 (10.00%)
9	10	11	12
-	1 (5.00%)	1 (5.00%)	1 (5.00%)
13	14	15	16
1 (5.00%)	3 (15.00%)	5 (25.00%)	3 (15.00%)

Fig. 5. Localisation of small openings.

10.27 per liver. In these cases we could not identify the vein.

Localisation of the openings

Figures 2–6 show the localisation of the openings in each area of the retrohepatic segment of the IVC. We

1 3 (0.97%)	2 6 (1.95%)	3 2 (0.65%)	4 10 (3.24%)
5 19 (6.17%)	6 25 (8.12%)	7 25 (8.12%)	8 29 (9.42%)
9 22 (7.15%)	10 47 (15.26%)	11 37 (12.01%)	12 19 (6.17%)
13 8 (2.60%)	14 26 (8.44%)	15 20 (6.49%)	16 10 (3.24%)

Fig. 6. Localisation of minimum openings.

1 8 (2.05%)	2 10 (2.56%)	3 3 (0.77%)	4 13 (3.34%)
5 23 (5.90%)	6 31 (7.95%)	7 30 (7.70%)	8 35 (8.98%)
9 24 (6.15%)	10 60 (15.38%)	11 41 (10.51%)	12 21 (5.38%)
13 9 (2.31%)	14 31 (7.95%)	15 32 (8.20%)	16 19 (4.87%)

Fig. 7. Localisation of ILO, medium, small and minimum openings.

1 ◆◆—15 □◆◆—04 ◆—03 ◆—02	2 ◆◆—09 ◆◆—01 ○—01 ◆—01	3 □—20 †—01	4 □—05 ○—02 †—01
5 ●—04 ◆◆—01	6 ●—06 †—01	7 †—03 □—02	8 ○—04 †—03
9 ●—02	10 ●—13 †—01	11 †—05	12 †—02
13 ●—01	14 ●—02 †—02	15 †—11	16 †—09

Fig. 8. Points of openings of hepatic veins and number of cases. □ Right hepatic vein; ◆ left hepatic vein; ◆ middle hepatic vein; † right posterosuperior; ● caudate vein; ○ right superior; † right posteroinferior.

illustrated the number of openings and their percentage in each area. Figure 7 illustrates the localisation of ILO, medium, small and minimum openings.

We determined the points of opening of the hepatic veins; these are presented in Figure 8.

## DISCUSSION

The average length of the retrohepatic segment was 6.7 cm, i.e. less than the 7.1 cm average value found by Chang et al. (1989). In 73.3% of cases, the axial direction from the retrohepatic segment was oblique to the left, a value similar to the 75.0% rate reported by Chang et al.

In 30.0% of the livers, the retrohepatic substance enclosed the entire width of the IVC, whereas Chang et al. obtained a rate of 6.7%. The average length and thickness of the enclosing retrohepatic substance were 3.2 and 0.7 cm, respectively, values similar to those reported by Chang et al., i.e. 2.5 and 0.5 cm, respectively. When the IVC was not totally enclosed, the width of the exposed posterior wall was 1.0 cm on average, very close to the 1.2 cm value reported by Chang et al.

Considering the superior openings of the IVC, the average values of the anteroposterior and transverse diameters were 1.6 and 5.5 cm, respectively smaller and larger than the values of 2.5 and 4.5 cm reported by Nakamura & Tsuzuki (1981). The average anteroposterior diameter was somewhat smaller than the 1.8 cm reported by Chang et al.

## Hepatic vein openings

According to Testut (1923) and Warwick & Williams (1973), the hepatic veins are divided into 2 groups in terms of location, i.e. superior and inferior. The first group empties into the IVC through large openings, and the second group through small openings. We noted the large openings in the superior segment, like Chang et al. (1989), but we found only 9 large openings in the inferior segment (ILO) in 30 livers, as opposed to 32 ILO in 60 livers observed by Chang et al. According to these authors, the presence of SLO as well as ILO is of significance in liver surgery and during hepatic pressure measurement or venography.

We found an average of 14.7 openings per liver, higher than the 8.2 value reported by Chang et al. The frequencies of 11.8% for SLO, 2.0% for ILO and 12.0% for the medium openings obtained here were

lower than those observed by Chang et al., i.e. 25.4, 6.5 and 20.1%, respectively. In contrast, the frequency of 74.2% for the openings whose widest diameter was less than 0.5 cm was higher than the 48.0% value obtained by Chang et al. The percentages of hepatic veins draining through SLO, ILO and medium openings, and their patterns are listed in Tables 1–4, and compared with those reported by Chang et al.

Concerning the SLO patterns, Chang et al. found only single, double and triple openings, although Guo (1981) observed the quadruple opening. We noted 2 of these openings: one in area 1 which consisted of 3 LHV and 1 MHV, and the other in area 2 which consisted of 2 LHV, 1 MHV and 1 RHV. According to the nomenclature used by Gibson (1959), Chang et al. found that the SLO could be divided into two types of ostium: left ostia, i.e. openings of the combined MHV and LHV, and right ostia, i.e. openings of the RHV. Gibson (1959) observed an average of 13 mm for the large diameter of the left ostia, and 15 mm for the right ostia. Chang et al. observed an average of 1.6 cm for the left ostia and an average of 1.8 cm for the right ostia. We found an average of 1.4 and 1.5 cm, respectively.

Excluding the SLO, the other openings were more prevalent in some areas, such as areas 6–8, 10, 11, 14 and 15, with 66.7% frequency. Chang et al. noted 64.0% of the openings in areas 2, 6, 10, 14, 15 and 16, as opposed to 46.9% in our study. ILO openings were more prevalent in areas 6 and 7, with 55.6% frequency, whereas Chang et al. detected 59.4% of all ILO in areas 15 and 16.

We found 52.8% of the medium openings in areas 6, 10, 14, 15 and 16, a lower frequency than the 82.8% value observed by Chang et al. in the same area, and verified that 60.0% of the small openings were in the inferior quarter of the IVC retrohepatic segment (areas 13–16; Fig. 5). The highest concentrations of the minimum openings (72.4%) were in the 2 median quarters (areas 5–12) (Fig. 6).

Other authors (Goldsmith & Woodburne, 1957; Warwick & Williams, 1973; Kennedy & Madding, 1977; Gupta et al. 1981; Nakamura & Tsuzuki, 1981) have reported the presence of the caudate veins and others veins through ILO, medium and small openings, but only Chang et al. documented the location of the hepatic veins.

Elias & Sherrick (1969) reported that the caudate lobe is drained by the superior and inferior venae hepaticae caudatae, which often converge towards a common opening in the left wall of the IVC, but occasionally empty separately. Chang et al. and Goldsmith & Woodburne (1957) both reported that

caudate lobe drainage is independent. We agree with these investigators but in 1 case we found a medium opening in area 5 which had 2 hepatic veins, caudate and MHV. Heloury et al. (1988) observed 4 different cases: 2 in which the caudate vein emptied into the LHV, 1 in which the caudate vein and the MHV formed a common trunk and 1 in which the caudate vein emptied into the right posteroinferior vein.

With respect to the localisation of the hepatic veins, we noted that the caudate vein was in areas 5, 6, 9, 10, 13 and 14, or better, in the 3 inferior quarters of the left half of the retrohepatic segment of the IVC, whereas Chang et al. found it on the anterior left wall. The caudate vein also is the most common in ILO, with 4/9 cases (44.5%), in contrast to Nakamura & Tsuzuki (1981) who found that the widest diameter of these veins was less than 0.8 cm. The right posteroinferior hepatic vein was predominantly observed in the right half of the retrohepatic segment, and 76.5% of these veins were found in areas 11, 12, 15 and 16, while Chang et al. noted 86.1% of these veins in areas 15 and 16. The right superior veins drained to areas 4 and 8, i.e. in the posterior and superior part of the right half of the retrohepatic segment, although Chang et al. also noted them in area 16. While the left and middle hepatic veins drained alone or together into the superior quarter of the left half of the retrohepatic segment, the right hepatic vein predominantly drained into the superior and right half of this wall.

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