Gross anatomy of the retrohepatic segment of the inferior vena cava in northwest Indians

Daisy Sahni, Harjeet, Y.K. Chawla* & Indar Jit

Departments of Anatomy & *Hepatology, Postgraduate Institute of Medical Education & Research, Chandigarh, India

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Background & objectives: Information regarding the size and position of the ostia of veins opening into the retrohepatic segment of inferior vena cava (HIVC) in northwest Indians is not available. Knowledge of gross anatomy of this segment is of importance in cases of segmental resection of the liver involving the groove for inferior vena cava (IVC) and when performing selective hepatic venography. We carried out this study to provide information on gross anatomy of HIVC in northwest Indians.

Methods: Livers were obtained from 500 adult autopsy subjects. The HIVC was opened posteriorly by a vertical cut and its circumference at the upper and lower cut ends was measured. To study the position of the ostia of the hepatic veins, HIVC was divided transversely into upper, middle and lower thirds. The anterior and anterolateral walls of HIVC were also divided into four equal parts longitudinally. The venous ostia were classified according to the size of their openings. In addition, in 100 livers the openings were injected with a 20 per cent solution of cellulose acetate butyrate (CAB) in acetone and veins were dissected.

Results: The HIVC extended upwards and to the left either obliquely (66.4%) or by describing a gentle curve (33.6%) in its upper half or upper third. Its average length was about 71 mm. Mean diameter at the upper cut end was about 19 mm. The posterior aspect of the upper half or upper one third of HIVC was covered by an extension of the caudate lobe completely (4%) or incompletely (7.4%). The ostia of the left, middle and right hepatic veins were large (> 10 mm) and were located in the upper third segment of HIVC. In 87 per cent of specimens the left and middle hepatic veins had a common opening on the left anterior area. The ostium of the right hepatic vein was present in the right anterior area.

Interpretation & conclusion: In conclusion, our study provided gross measurements of HIVC in northwest Indians. A knowledge of the anatomy of HIVC and hepatic venous ostia will help the clinician interventional operator in planning the treatment by choosing a balloon of correct size and at correct site. The measurements helps in determining the fall in portal pressure with pharmacotherapy given for the prevention of variceal bleed.

Key words Hepatic venography - inferior vena cava - liver - northwest Indians - veins
The retrohepatic segment of the inferior vena cava (HIVC) lies in a groove in the posterior part of the liver between the caudate lobe (CL) and the right lobe (RL). Inferior phrenic, hepatic and usually the right suprarenal veins open into this segment. Several workers\textsuperscript{1-5} have stressed the importance of the study of the venous ostia in this segment, as their occlusion by a membrane may give rise to Budd-Chiari syndrome. Gross anatomy of this segment is also of importance in cases of segmental resection of the liver involving the groove for inferior vena cava (IVC) and when performing selective hepatic venography.

Textbooks of anatomy do not mention the direction this segment of IVC takes at its upper part. Also, measurements of this segment of IVC are not available. Instead of passing in a groove, the HIVC may, sometimes partially or completely tunnel the liver. Considerable work has been done on this segment of the liver in some countries including Japan\textsuperscript{2}, China\textsuperscript{3} and Brazil\textsuperscript{5}. The racial and sexual variations of the anatomical structures are well known; as also have been reported by us\textsuperscript{6-10}. In India, though hepatic veins have been described\textsuperscript{11-13}, this important segment of IVC has not received any attention. We therefore undertook this retrospective study to provide data on the HIVC including the size and position of the ostia of veins opening into it in northwest Indians.

**Material & Methods**

Material for the present study consisted of apparently healthy livers obtained from 500 adults (350 males, 150 females), age range 18 and 80 yr on whom a medicolegal postmortem had been conducted at the Postgraduate Institute of Medical Education & Research, Chandigarh during the period 1981-1991. The subjects were residents of the Chandigarh zone of northwest India. With informed consent of the relatives of the deceased, the liver along with IVC and diaphragm were removed at autopsy. Caudally, the IVC was divided transversely at the lower end at the level of the posterior border of caudate process (CP) and cranially where it pierced the diaphragm. The axial length and direction of HIVC were noted. The number of the specimens in which the HIVC was covered by the liver substance posteriorly was recorded. The HIVC was opened posteriorly by a vertical cut extending from its upper to the lower end. The specimen was washed under running tap water to remove all clots of blood from HIVC and from the venous ostia. The side to side breadth at both ends was measured with a divider to get the circumference from which diameters were calculated. The size and position of venous ostia of various hepatic veins were studied. Attempt was made to find out the percentage of cases showing the opening of left hepatic vein (LHV) and middle hepatic vein (MHV) and their relationship to right hepatic vein (RHV) was sought. Common openings of right supra renal vein (RSRV) with posterior superior vein (PSV) or posterior inferior vein (PIV) and caudate superior vein (CSV) with caudate inferior vein (CIV) were also noted. The ostia were classified according to the size of their openings: large with at least one diameter of more than 10 mm, medium with a diameter between 5 and 10 mm and small with a diameter of 1 to 5 mm. In addition, there were some very small venous openings, the diameter of which could not be determined. Nomenclature used for the hepatic veins is the same as given earlier\textsuperscript{13}. To indicate the relative position of the venous ostia, the HIVC was divided transversely into three equal parts - upper, middle and lower thirds. The anterior and lateral walls were also divided into four equal areas vertically: left lateral (LLat), left anterior (LAnt), right anterior (RAnt) and right lateral (RLat). The posterior and posterolateral walls were ignored as there were no openings thereon. Thus, there were 12 areas in all (Fig. 1). While the diameters of the ostia of the large veins were measured with a Vernier caliper, those of the medium and small veins were determined by inserting stiff plastic tubes of known diameters and by calibrated metallic cones already described\textsuperscript{6}. To verify the nomenclature of the hepatic venous openings, in 50 male and 50 female livers, the large, medium and small venous openings were injected with a 20 per
cent solution of cellulose acetate butyrate (CAB) in acetone and the veins were dissected. The data were analyzed using SPSS software. Statistically sexual differences were calculated for mean axial length, extension of caudate lobe covering the HIVC and mean diameter of HIVC at its upper and lower ends.

**Results**

**Inferior vena cava:** The HIVC was present in a broad groove between RL and CL. It extended upwards and to the left either obliquely (66.4%) or by describing a gentle curve in its upper half or upper one-third (33.6%) of its length (Figs 2, 3). There was no specimen in which it was vertical. Its mean axial length was 72.4 ± 11.8 mm (range 50-90 mm) in male and 70.5 ± 9.5 mm (range 50-75 mm) in female livers ($P > 0.05$). In 42 (12%) male and 15 (10%) female specimens, CL extended to the right covering posteriorly the upper third or upper half of HIVC. In 15 (4.3%) male and 5 (3.3%) female livers the extension was complete; it either had a free border covering the right lobe (Fig. 4) or merged with the latter (Fig. 5), thus constituting a complete tunneling of the liver by HIVC. In the remaining specimens, the extension, which had a right free border covered it incompletely (Fig. 6). The thickest part of the extension was at its commencement, which measured from 1 to 3 mm. The lower one-third of HIVC,

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**Fig. 1.** Diagrammatic representation of the hepatic segment of inferior vena cava (HIVC) showing the size and position of the hepatic venous ostia in the prevailing pattern. The IVC has been divided into three equal parts: upper, middle and lower, and four equal parts vertically, left lateral (L lat), left anterior (L ant), right anterior (R ant) and right lateral (R lat). LHV, left hepatic vein; RHV, right hepatic vein; MHV, middle hepatic vein; CSV, caudate superior vein; CIV, caudate inferior vein; VCP, vein of caudate process; PSV, posterior superior vein; PIV, posterior inferior vein; RSRV, right suprarenal vein; DV, dorsal vein.

**Fig. 2.** Photograph of the posterior surface of the liver. A probe in the IVC indicates its oblique direction.

**Fig. 3.** Posterior surface of the liver showing the opened IVC which is curved in its upper part.
Hepatovenous openings:

Large openings - The large hepatic veins, which opened into HIVC were right hepatic (RHV), left hepatic (LHV) and middle hepatic (MHV) veins. In 87 per cent of instances LHV and MHV had a common opening. Whether the openings were common or separate, they were present on the LAnt area of upper third of HIVC. When separate the opening of MHV was located on the right of the opening of LHV; the distance between the two ostia varied from zero (when only a septum was present) to 5 mm. The opening of RHV always existed in the RAnt area of upper third of HIVC. The upper margin of LHV or combined LHV and MHV was higher than that of RHV by an average distance of 5.6 ± 2.4 mm (range 2-19 mm) in 54 per cent of instances. Reverse was the case in 28 per cent cases when upper margin of HIVC was higher on an average by 6.5 ± 2.3 mm (range 2-10 mm). The upper margins of both the openings were at the same level in 18 per cent instances. The average horizontal distance between the right margin of LHV (or combined LHV and MHV) and the left margin of RHV was 9.2±2.37 mm (range 6-15 mm).

however, remained uncovered in all specimens. The calculated mean diameter of the HIVC at its upper cut end was 19.42 ± 4.2 mm (range 15 - 32 mm) in the males and 18.98 ± 3.9 mm (range 14-28 mm) in the females (P > 0.05). The diameter of HIVC at its lower cut end was 18.88 ± 2.3 mm (range 16-30) in the males and 18.18 ± 3.2 mm (range 15-26 mm) in the females (P > 0.05).
Posterior superior vein (PSV) - The opening was small in 81 per cent and of medium size in 9 per cent of instances. It was absent in 10 per cent of specimens. The opening was present in the middle third of HVC, in the RLat area in 82 per cent of cases and in RAnt area in 8 per cent of instances.

Posterior inferior vein (PIV) - The opening was small in 82 per cent of instances, of medium size in 9.6 per cent of specimens and of large size in 0.4 per cent of cases; it was absent in 8 per cent of livers. The ostium was present in the lower third of HVC in RLat area in 53 per cent of specimens and in RAnt area in 39 per cent of instances. When present in RLat area it was at an average distance of 22.5 ± 10.1 mm (range 14 - 48 mm) below the opening of PSV.

Right suprarenal vein (RSRV) - Although the RSRV was present in all instances, its ostium in HVC was seen in 78 per cent of the livers. In the remaining specimens the vein had joined either PSV or PIV. Its ostium was always of small size and was present in middle third of HVC in the RLat area in 64 per cent of instances and in RAnt area in the remaining 14 per cent of specimens.

Dorsal vein (DV) - The ostium of DV was identified in 55 per cent of specimens and was located about the middle of right and left anterior areas of the lower third of HVC. Its opening was small in size in 42 per cent and of medium size in 13 per cent of instances. It was absent in 45 per cent of specimens.

Caudate superior vein (CSV) - The opening of CSV was small in size in 54 per cent of specimens and of medium size in 10 per cent of cases. It had two small openings in 7 per cent of livers and in 25 per cent of specimens the ostium was common with that of caudate inferior vein (CIV). It was absent in 4 per cent of instances. When separate its ostium was located in the middle one-third of HVC in 80 per cent of cases in LAnt area and in the remaining specimen in the LLat area. When the vein had a common opening with that of CIV or had two small openings, they were also located in the LAnt area of middle one-third of HVC.

Caudate inferior vein (CIV) - When separate the opening was small sized in 67 per cent of livers and of medium size in 8 per cent of cases. It was located in the lower one-third of HVC in LAnt area in 65 per cent and in LLat in 10 per cent of instances. The combined opening of CSV and CIV was seen in 25 per cent of instances; it was of medium size and was located in the LAnt area of middle one-third of HVC.

Vein of the caudate process (VCP) - The ostium was always of small size. It was not seen in 12 per cent of cases. When present it always opened in the LAnt area of lower third of HVC.

Right superior hepatic vein - In 7 per cent instances, there was another small opening located just lateral to the opening of RHV. On dissection it was found to be right superior hepatic vein, which had not joined the RHV.

Very small veins - Very small veins, the caliber of which was pinpoint, opened in all the areas of HVC except LLat and RLat areas of upper third of HVC. In an area, their number was variable (1-4). The total number of very small veins in a specimen varied from zero to 18.

Discussion

Hepatic segment of IVC: Table I gives a comparison between the present observations regarding the length, axial direction and diameters of HVC at its two ends. In our series the average length of HVC was almost the same as in the livers of Chinese and Brazilians13. The direction of HVC was vertical in some Chinese and Brazilian livers but we did not find such instances; this may be due to a racial difference. The direction of HVC was oblique in three-fourth of Brazilian livers as compared to only one-sixth of the Chinese livers. In the present study the obliquity was seen in the upper one-third of HVC in 66.4 per cent of instances. It was curved only in 13.3 per cent of Brazilian livers as compared to 75 per cent of Chinese and 33.6 per cent of northwest Indian specimens. There is hardly any difference in the
diameters of upper end of HIVC in the three populations; diameters at the lower end are not given in other studies. Statistically, no sexual difference was found between the diameters at the two ends of HIVC in northwest Indian population \((P>0.05)\). A complete tunneling was present in about one-third of the specimens in Brazilian study\(^5\) as compared to only a few instances in Chinese\(^3\) and northwest Indian livers; however, the incidence of incomplete tunneling was much higher in Chinese and Brazilian studies\(^3,5\) in comparison to the present northwest Indians. The incidence of complete tunneling of the liver by HIVC seems to be variable in different populations. In the present series the HIVC was not embedded within the liver substance in 88 per cent of male and 90 per cent of female livers. Also in northwest Indians, the lower one third of HIVC always remained uncovered posteriorly by the hepatic extension; this situation has not been reported in the Chinese and Brazilian populations.

Large veins: Hepatic veins and the areas of the liver drained by them have been extensively studied in various parts of the world\(^2,12-14\). The incidence of a common ostium of LHV and MHV, although somewhat variable in various populations was very high (Table II). A common opening for RHV, LHV and MHV was observed in some of Brazilian specimens but has not been reported in other populations. In the present series also we did not observe any specimen where all the three large hepatic veins had a common opening. In 5-6 per cent of Japanese livers right superior vein opened directly into IVC\(^2\). We found 7.0 per cent of instances in which the right superior hepatic vein opened directly into HIVC.

Posterior superior and inferior veins: Though the opening of PIV was usually large in the Japanese, the ostia of other posterior veins were of variable size\(^2\). In Chinese, the size of the ostia of PSV and PIV were usually of medium size but some of them were also large\(^3\). In Brazilian livers there were three (10.0\%) instances in which PIV was of large size and in twenty (66.7\%) specimens the opening was of medium size\(^3\). In the present study the openings of both PSV and PIV were of small size in more than 80 per cent of instances; it was of medium size in about 9-10 per cent of cases; while PIV was large in only 0.4 per cent of specimens (Table II). Further, in the present series, the opening of PSV was present in the middle third of HIVC in RLat area in 82 per cent of cases and in RAnt area in remaining 8 per cent of instances. The opening of PIV was present in the lower one-third of HIVC in the RLat area in 53 per cent of cases and in RAnt area in 39 per cent of instances.

Right suprarenal vein: In Japanese study\(^2\) the RSRV opened directly into HIVC in 74.4 per cent of instances while in the remaining specimens it joined one of the right posterior veins. In the present material, there was only one RSRV in each specimen, it directly opened into HIVC between the openings of PSV and PIV in 78 per cent instances while in the remaining specimens it either joined PSV or PIV.

### Table I. Comparison between the present findings on hepatic segment of inferior vena cava (HIVC) with other studies

<table>
<thead>
<tr>
<th>Populations</th>
<th>N</th>
<th>Average length (mm)</th>
<th>Axial direction of HIVC (%)</th>
<th>Diameter of HIVC (mm)</th>
<th>Incidence of tunneling (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vetical</td>
<td>Oblique</td>
<td>Curved</td>
</tr>
<tr>
<td>Chinese(^3)</td>
<td>60</td>
<td>71.0</td>
<td>8.33</td>
<td>16.67</td>
<td>75.00</td>
</tr>
<tr>
<td>Brazilian(^1)</td>
<td>30</td>
<td>67.0</td>
<td>13.3</td>
<td>73.3</td>
<td>13.3</td>
</tr>
<tr>
<td>Northwest Indian</td>
<td>M-350</td>
<td>72.4 ± 11.8</td>
<td>(50-90)</td>
<td>Nil</td>
<td>66.4</td>
</tr>
<tr>
<td>(present study)</td>
<td>F-150</td>
<td>70.5 ± 9.5</td>
<td>(50-75)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values in parenthesis indicate range; M, male; F, female
Superscript numerals represent reference numbers
**Dorsal vein:** The ostium of DV seems to have not attracted the attention of the previous workers. We found it of small size in 42 per cent and of medium size in 13 per cent instances.

**Caudate veins:** The openings of caudate veins were of medium size in most of the Chinese and Brazilian livers and of large size only in some instances. In Chinese livers, the ostia were on the LAnt wall of HIVC, while in Brazilian livers they were located in ‘three inferior quarters’ of the left half of HIVC. According to Elias and Sherrick, CSV and CIV often opened by a common ostium into HIVC but occasionally empty separately on its left wall. Japanese workers observed only one ostium of the veins from CL in 36.6 per cent instances, 2 in 37.8 per cent and 3 or 4 in 25.6 per cent of cases; they did not take into account a separate vein from the CP. In the present material, the openings of CSV and CIV were mostly of small size but they were of medium size in some instances. While the ostium of CSV was present in the LAnt area or LLat area of the middle third of HIVC; the opening of CIV was seen in the same areas of lower third of HIVC.

In chronic Budd-Chiari syndrome there is obstruction to the hepatic venous blood outflow. This obstruction could be due to the presence of a membrane in the IVC or large hepatic veins i.e., RHV, MHV or LHV. In a study on 177 cases of Budd-Chiari syndrome, membranous obstruction was seen in 54 instances in this institution during 1967-1991. Earlier treatment consisted of rupturing the membrane by transcardiac “finger-fracture” method or creation of a mesocaval shunt. As these methods involved a high morbidity they were replaced by balloon membranotomy and stenting. A knowledge of the size and position of the venous ostia will help the interventional operator to choose a balloon of correct size and at correct site. These measurements help in determining the fall in portal pressure with pharmacotherapy given for the prevention of variceal bleed. Caudate lobe enlargement is well known in hepatic venous outflow tract obstruction. As a result

### Table II. Comparison between the present findings of the common openings, size and number of the hepatic ostia in HIVC with other studies

<table>
<thead>
<tr>
<th>Populations</th>
<th>N</th>
<th>Common ostia of hepatic veins (%)</th>
<th>Size of the ostia* (%)</th>
<th>Average no. of openings in HIVC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LHV + RHV + MHV</td>
<td>PSV</td>
<td>PIV</td>
</tr>
<tr>
<td>Japanese²</td>
<td>83</td>
<td>84.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chinese³</td>
<td>60</td>
<td>88.3</td>
<td>Usually medium</td>
<td>Usually medium</td>
</tr>
<tr>
<td>Brazilian³</td>
<td>30</td>
<td>70.0 13.3</td>
<td>M-2.0 L-10.0 M-66.0</td>
<td>M-66.0</td>
</tr>
<tr>
<td>Northwest Indian¹</td>
<td>153</td>
<td>88.2</td>
<td>Nil</td>
<td>-</td>
</tr>
<tr>
<td>Northwest Indian</td>
<td>500</td>
<td>87.0</td>
<td>S-81.0 M-9.0 S-82.0</td>
<td>S-81.0 M-9.0 S-82.0</td>
</tr>
</tbody>
</table>

Superscripts numerals represent reference numbers
N, no. of subjects; L, large; M, medium; S, small
*RHV, MHV and LHV were always of large size in all the populations; **common opening of CSV and CIV
LHV, left hepatic vein; MHV, middle hepatic vein; RHV, right hepatic vein; PSV, posterior superior vein; PIV, posterior inferior vein; DV, dorsal vein; CSV, caudate superior vein; CIV, caudate inferior vein; VCP, vein of caudate process
of a compensatory hypertrophy, the caudate lobe veins, in some cases, become dilated and decompress the congested liver into the IVC thereby relieving the Budd-Chiari patients of ascites and esophageal varices.

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References


Reprint requests: Dr. Daisy Sahni, Additional Professor, Department of Anatomy, Research Block-B, Postgraduate Institute of Medical Education & Research, Chandigarh 160012, India e-mail: daisy_sahni@rediffmail.com