Surgical anatomy of retrohepatic inferior vena cava and hepatic veins: a quantitative assessment

DHANANJAYA SHARMA, ABHIJEET DESHMUKH, V K RAINA

Department of Surgery, Government Medical College, Jabalpur, Madhya Pradesh 482 003

Background: Accurate knowledge of the surgical anatomy of the retrohepatic inferior vena cava (IVC) and hepatic veins is necessary for hepatic surgery. Methods: Lengths of different segments of retrohepatic IVC and their diameters, and prevalence of various types of ramification and lengths of different hepatic veins, were noted in 100 disease-free human livers during autopsy. Results: The mean lengths of the IVC from entry into atrium to diaphragmatic hiatus, from the hiatus to the upper margin of right hepatic vein, between the upper margins of the right hepatic vein and the right suprarenal vein, from right suprarenal vein to the lowermost dorsal hepatic vein, and from the lowermost dorsal hepatic vein to the right renal vein were 29.1 mm, 8.6 mm, 40.6 mm, 28.6 mm and 33.7 mm, respectively. The mean diameter of IVC at the diaphragmatic level was 30.1 mm. The commonest ramification pattern of the hepatic veins was type I (82%) for the right hepatic vein, type II (63%) for the middle and left hepatic veins, and type II (55%) for the cavae veins. In 96% of cases the middle and left hepatic veins formed a common trunk. In a majority of cases, the diameters of the right and left hepatic veins were between 7 mm and 12 mm. No gender differences were found. Conclusion: This study provides an anatomical perspective for various hepatic surgical techniques. [Indian J Gastroenterol 2001;20:136-139]

Key words: Hepatic surgery

Accurate knowledge of the surgical anatomy of the hepatic veins and retrohepatic inferior vena cava (IVC) is necessary for safe hepatic surgery; this is even more important in developing countries where imaging facilities to detect variations may be suboptimal. There is a renewed interest in this view in the anatomy of the increasing number of liver resections for hepatic diseases and for reduced-size liver transplantation. Despite its significance, available information about the anatomy of these vessels is relatively scant. We therefore studied variations in the surgical anatomy of the retrohepatic IVC and hepatic veins.

Methods

One hundred cadavers were examined at autopsy, from persons who had no liver disease. The age of the deceased persons (57 men) ranged from 17 to 75 years (mean 46).

The abdomen was opened through a midline incision and the anterior thoracic wall was removed to expose the intra-abdominal and intrathoracic organs. The IVC was exposed from the right atrium to the level of its junction with the renal veins, and the length of its various segments were measured:

a. From the entry of the IVC into the right atrium to the diaphragmatic hiatus (supradiaphragmatic segment of IVC).
b. From the diaphragmatic hiatus to the upper margin of the right hepatic vein (infra-diaphragmatic segment of IVC).
c. From the upper margin of the right hepatic vein to the right suprarenal vein.
d. From the right suprarenal vein to the lowermost dorsal hepatic vein.
e. From the lowermost dorsal hepatic vein to the right renal vein.

The diameter of the IVC at the diaphragmatic level was also recorded.

After this, the liver and the IVC were extirpated en bloc and exteriorized. The posterior wall of the IVC was cut in a longitudinal direction. The lumen of the IVC was opened, and the diameters of the right, middle and left hepatic veins at their junctions with the IVC, and the patterns of ramification and distribution of these hepatic veins were recorded. Ramifications of the hepatic veins were classified as described previously; this classification is described in brief below.

Right hepatic vein (Fig 1)

Type I: No ramification within 1 cm of IVC; type IIa: right superior vein within 1 cm from IVC; type IIb: right antero-superior vein within 1 cm from IVC; type III: both right superior and right antero-superior veins within 1 cm from IVC; type IV: has two veins – one, the right hepatic vein with a branch of the right antero-superior vein and the other, an independent right superior vein flowing directly into the IVC.

Middle and left hepatic veins (Fig 2)

The middle and the left hepatic veins form a common trunk in most patients.

Type I: no ramification within 1 cm from the IVC; type II: two ramifications within 1 cm from IVC; type...
III: trifurcation within 1 cm from IVC; type IV: quadrifurcation within 1 cm from IVC; type V: independent left and middle hepatic veins joining IVC.

Veins of caudate lobe (Fig 3)

Type I: only one vein; type IIa: two veins arranged in longitudinal direction; type IIb: two veins arranged in transverse direction; type III: three or four veins.

Results

The mean (SD) length of the IVC segments is given in Table 1. The mean diameter of the IVC at the diaphragmatic level was 30.1 (2.4) mm (range 25 to 39).

Type I ramification of right hepatic vein was found in 82% of cases. In 18%, a ramification was found within 1 cm of the IVC (Table 2). In 96% of cases the middle and left hepatic veins formed a common trunk. The commonest ramification pattern of these veins was type II (65%). The length of the common trunk of the middle and left hepatic veins was under 10 mm in most cases, the mean (SD) length being 9.8 (1.2) mm (range 4 to 13). The mean diameters of the right, middle and left hepatic veins were 10.0 (1.9) mm (range 8 to 19), 8.3 (1.4) mm (range 6 to 13) and 7.5 (1.2) mm (range 5 to 10), respectively.

The most common pattern of caudate veins was type II (55%); the prevalence of types I and III was 31% and 14%, respectively. The dorsal hepatic veins
Fig 3: Classification of patterns of ramification of veins of the caudate lobe (Used with permission from Nakamura S, Tsuzuki T. Surgical anatomy of the hepatic veins and the inferior vena cava. Surg Gynecol Obstet 1981;152:43-50)

Table 2: Prevalence of various types of ramification of right (RHIV), middle (MHIV) and left (LHIV) hepatic veins

<table>
<thead>
<tr>
<th>Types</th>
<th>RHIV % incidence</th>
<th>MHIV/LHIV % incidence</th>
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<tbody>
<tr>
<td>I</td>
<td>82</td>
<td>17</td>
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<tr>
<td>II</td>
<td>10</td>
<td>65</td>
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<tr>
<td>III</td>
<td>4</td>
<td>16</td>
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<tr>
<td>IV</td>
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(mean number 13 [4], range 6 to 38) were found entering the IVC over a distance of 6.5 cm to 7.5 cm.

No gender differences were found in length and ramification pattern.

Discussion

Laceration of and torrential hemorrhage from hepatic veins and retrohepatic IVC remain much-feared events during hepatic resections. Knowledge of anatomy finds application in segmental, conventional and complicated liver resections using selective, intermittent or total vascular exclusion of the liver. Attention to anatomical variation in the hepatic veins avoids not only bleeding but also air embolism, in case of injury to one of the hepatic veins.

During vascular exclusion of the liver, clamping of the suprahepatic IVC is dependent on the site at which the clamp is applied in relation to the diaphragm; an abdominal approach is possible in a majority of cases, the mean length of the suprahepatic infradiaphragmatic IVC being 9.8 mm. However, various inflow patterns of phrenic veins joining the IVC at this level may cause difficulty. In case of lack of space for clamping, the diaphragm can be split; clamping or taping of the supra-diaphragmatic segment of the IVC is then easy because of the absence of any inflow vein in this location.

Clamping of the IVC above the renal veins can be easily performed, although attention should be paid to the pattern of the right suprarenal vein. The mean distance between the upper margin of the right hepatic vein and the right suprarenal vein was 40.6 mm. However, clamping or taping should be performed with care when the right suprarenal vein joins the IVC in close proximity to the renal vein.

We found that the diameter of the IVC at the level of the diaphragmatic hiatus varies from 25 mm to 39 mm; others have reported diameters varying from 25 mm to 45 mm.

This knowledge of anatomy allows classification and helps in the treatment of liver injuries. The dorsal hepatic veins enter the IVC over a distance of 6.5 cm to 7.5 cm, requiring exposure of the entire retrohepatic IVC for surgical exploration of blunt hepatic injury.

Ramification patterns of the various hepatic veins have implication in deciding whether these veins can be ligated outside the liver before dividing the hepatic parenchyma or not. The right hepatic vein, lacking a collateral for over 1 cm external to the liver in a majority of cases (type I = 82%), can be controlled outside the liver after mobilization of its right lobe, but caution is needed in tackling a vein with a mean diameter of 10 mm. It is important to emphasize that the type I pattern is the only safe pattern for ligation of the vein outside the liver. The frequency of type I ramification of the right hepatic vein in other studies varied from 50% to 61.4%. Nakamura and Tsuzuki noted the frequency of type II and III ramifications as 22.8% and 9.8%, respectively. The much-feared “accessory” right hepatic vein (type IV ramification) was noted by us in just 4% of cases; others have found it in 6% to 20% of cases.

Control of the hepatic veins external to the liver on the left side, although practised by some surgeons, is dangerous since a common trunk between the middle and left veins is frequent (96%); the length of the trunk
is less than 1 cm in most cases and the mean diameter is 9.8 mm. Others have also noted the presence of such a common trunk in 70% to 90% of cases.\textsuperscript{2,10} The commonest ramification pattern in other studies was also type II (42.2%).\textsuperscript{2} The length of the common trunk in other studies was 5 mm to 10 mm.\textsuperscript{2,10} Middle and left hepatic vein variations are also relevant in donor hepatectomy for liver-related liver transplantation.\textsuperscript{10}

Delineation of this complex venous anatomy is of paramount importance because the hepatic veins have to be transected in the correct plane. It is a safe practice to isolate and free the retrohepatic IVC before dissection of the main hepatic veins, so that dissection of hepatic veins can follow the correct plane of cleavage.\textsuperscript{5} The wide diameter and short length of the various hepatic veins requires secure closure by vascular suturing.\textsuperscript{2} Presence of ligamentous tissue (IVC ligament) around the right hepatic vein makes its exposure and secure ligature more difficult.

Anatomical complexities have implications for transplant techniques.\textsuperscript{3,4,11} The anatomical relations between the hepatocaval connection, diaphragm and right atrium define modalities in the treatment of hepatic lesions such as membranes in the terminal IVC and the Budd-Chiari syndrome.\textsuperscript{12} Other applications of this knowledge of anatomy include surgical treatment of malignant neoplasms of the kidney\textsuperscript{13} and adrenals,\textsuperscript{14} retroperitoneal lymph-node dissection,\textsuperscript{15} vascular surgical techniques applied to upper abdominal cancer surgery,\textsuperscript{16} treatment of primary or secondary tumoral occlusion of the IVC,\textsuperscript{17} and other operations on the hepatic veins and IVC.\textsuperscript{18}

Interpretation of preoperative ultrasonography or Doppler images of the hepatic veins depends on the individual's skill. Three-dimensional display of hepatic venous anatomy generated from spiral computed tomography data\textsuperscript{1} and intraoperative ultrasonography is informative but its availability in developing countries is limited to a few hospitals. This makes it even more crucial for surgeons working in developing countries to have accurate knowledge of surgical anatomy to ensure safe hepatic surgery. An anatomical study like this - the first in the Indian population - addresses the dual issues of determining the anatomical variations in a particular population as well as serving as an important reminder to surgeons embarking upon liver surgery.

References


Correspondence to: Dr Sharma, P-10, Medical College Campus, Jhabulpur (MP) 482 003. Fax: (761) 31 8975. E-mail: dhanashar@hotmail.com

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