Evaluation Of The Variations Of The Hepatic Veins
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Citation

Abstract
The liver, the largest organ in human body, plays a significant role in preserving the integrity of the body and its organs. This is thought to be the result of the complex functions the liver performs. Such functions include synthesis of blood proteins, secretion of bile and metabolism of end products of digestion transported by the blood through the portal circulation. The latter is very important since all blood from the gastrointestinal system passes first through the liver before going to the heart and to the systemic circulation. The blood enters the liver from two sources, the portal vein and the hepatic artery, and it leaves through the hepatic veins. The latter are of significant importance since they are considered the major link between the liver and the Inferior Vena Cava (IVC) and therefore between the portal and systemic circulations. Since the anatomical features of the hepatic veins are not constant and vary from one person to another, we aimed in this study to document the variations in number, size and location of the hepatic veins.

INTRODUCTION
The liver, the largest organ in human body, plays a significant role in preserving the integrity of the body and its organs. This is thought to be the result of the complex functions the liver performs. Such functions include synthesis of blood proteins, secretion of bile and metabolism of end products of digestion transported by the blood through the portal circulation. The latter is very important since all blood from the gastrointestinal system passes first through the liver before going to the heart and to the systemic circulation. The blood enters the liver from two sources, the portal vein and the hepatic artery, and it leaves through the hepatic veins. The latter are of significant importance since they are considered the major link between the liver and the Inferior Vena Cava (IVC) and therefore between the portal and systemic circulations.

Since the anatomical features of the hepatic veins are not constant and vary from one person to another, we aimed in this study to document the variations in number, size and location of the hepatic veins.

MATERIALS AND METHODS
The hepatic veins of 18 cadavers with normal liver morphology were examined. The livers and the hepatic segment of the IVC were first removed. The posterior wall of the IVC was removed to expose the anterior side of the lumen of the IVC. This was washed and cleaned to expose the opening of the hepatic veins which drain the liver. The hepatic veins were then classified into an upper group (also known as the main hepatic veins) and a lower group (also known as the accessory hepatic veins).

The diameter of veins was measured with a dial calliper. According to their location on the anterior wall of the IVC, the accessory hepatic veins were classified into superior or inferior right, superior or inferior left and superior or inferior intermediate hepatic veins. The main hepatic veins were also classified according to their location into right, left and middle hepatic veins.

Additional measurements were made included the distance between some hepatic veins and the length of the hepatic portion of the IVC. In addition, the tributaries of the hepatic veins were recorded if their openings could be seen. The distance between the union of these tributaries and the opening of the hepatic vein (the length of the common trunk) was also measured.

Finally, descriptive pictures of the anterior side of the lumen of the hepatic portion of the IVC with the location of the opening of the hepatic veins were drawn, and the data obtained were classified and presented in statistical format.

RESULTS
The total number of hepatic veins ranged from four to fifteen
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veins, with 44.4% of the specimens having seven to eight hepatic veins (tables 1a,1b,2). The number, size and location of the main hepatic veins were significantly different from those of the accessory hepatic veins (tables 1a,1b). Therefore, the results were classified according to which group the hepatic veins belong.

There are three main hepatic veins: right, middle and left. In this study 50% of the specimens had all of the three hepatic veins, while the remaining 50% had two hepatic veins: right and left (table 3a).

In those specimens with three main hepatic veins, the left and the middle veins opened into well demarcated oval area in 55.5% of them (table 3b). Thus, the combined percentage of the specimens with two hepatic veins or where the middle and left hepatic veins opened in the same area was 77.7%.

The major hepatic veins were always at the same level in the upper part of the hepatic portion of the IVC. In 50% of the specimens, the most superior vein was the main left hepatic vein (table 4). In subjects with three main hepatic veins, the middle hepatic vein tended to be closer to the left than to the right hepatic vein. In fact, the distance between the middle and the left hepatic veins was at least a third of that between the middle and the right hepatic veins. In addition, the distance between the middle and the left hepatic veins, in those specimens where they both open in well-defined area, was very small and accounted to the thickness of a thin septum separating both veins.

Table 1a: The aspects of the hepatic veins in the specimens 1-9

<table>
<thead>
<tr>
<th>SPECIMENS</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
<th>S7</th>
<th>S8</th>
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<tr>
<td>Number of hepatic veins</td>
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<td>5</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Number of main hepatic veins</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Largest main hepatic vein (cm)</td>
<td>Right</td>
<td>2.3</td>
<td>2.49</td>
<td>1.66</td>
<td>1.98</td>
<td>2.64</td>
<td>2.18</td>
<td>1.55</td>
<td>2.26</td>
</tr>
<tr>
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<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Left-middle main vein open in well defined area</td>
<td>No</td>
<td>-----</td>
<td>No</td>
<td>-----</td>
<td>Yes</td>
<td>-----</td>
<td>Yes</td>
<td>-----</td>
<td>Yes</td>
</tr>
<tr>
<td>Accessory vein draining left lobe</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
</tr>
<tr>
<td>Most superior main hepatic vein</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
</tr>
<tr>
<td>Most inferior accessory lv</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
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</tr>
</tbody>
</table>

Inf R= Inferior Right
Sup R= Superior Right
Sup L= Superior Left
Inf I= Inferior Intermediate

Table 1b: The aspects of the hepatic veins in the specimens 10-18

<table>
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<tr>
<th>SPECIMENS</th>
<th>S10</th>
<th>S11</th>
<th>S12</th>
<th>S13</th>
<th>S14</th>
<th>S15</th>
<th>S16</th>
<th>S17</th>
<th>S18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of hepatic veins</td>
<td>8</td>
<td>8</td>
<td>11</td>
<td>7</td>
<td>8</td>
<td>10</td>
<td>7</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Number of main veins</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
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<tr>
<td>Number of accessory veins</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Largest main hepatic vein (cm)</td>
<td>Right</td>
<td>1.82</td>
<td>1.92</td>
<td>1.92</td>
<td>1.5</td>
<td>1.34</td>
<td>2.71</td>
<td>2.13</td>
<td>2.02</td>
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<tr>
<td>The presence of middle vein</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Left-middle main vein open in well defined area</td>
<td>No</td>
<td>-----</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Accessory vein draining left lobe</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
</tr>
<tr>
<td>Most superior main HVs</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
</tr>
<tr>
<td>Most inferior accessory lv</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
<td>Inf R</td>
</tr>
</tbody>
</table>

Inf R= Inferior right
The diameter of the main hepatic veins was quite variable (tables 1a,1b). The diameter of the right hepatic vein ranged from 1.5 to 2.5 cm in 66.6% of the specimens (table 5a). The diameter of the middle hepatic vein was usually smaller, ranging from 1 to 1.5 cm in 77.7% of the specimens (table 5b). The diameter of the left hepatic vein was usually smaller than that of the right hepatic vein but larger than that of the middle hepatic vein. It ranged from 1 to 2 cm in 72.2% of the specimens (table 5c).

The right hepatic vein was the largest in 77.7% of the specimens. In the remaining 22.2%, the largest vein was the left hepatic vein (table 6). Surprisingly, even in those specimens where the middle and the proper left hepatic veins united to form a left hepatic vein, the largest vein was still the right hepatic vein in 77.7% of these cases (7 of 9 specimens).

The largest main hepatic vein was a right hepatic vein observed in one specimen. It’s diameter was 2.71 cm. The largest left hepatic vein found to be 2.18 cm in diameter.

The number of the accessory hepatic veins ranged from 1 to 13 veins (tables 1a,1b). Most often (38.8%), these were four to five accessory hepatic veins (table 7). The results of this study also showed that all the accessory hepatic veins drain either the right or the caudate lobes if they are situated at the right or the left side of the IVC respectively. The veins situated in the middle usually drain the caudate lobe as well.
There was one exception where there were two small upper accessory hepatic veins at the periphery of the main left hepatic vein, and they drained the left lobe. With the exception of one specimen in which there were no veins draining the caudate lobe, the number of the veins draining this lobe ranged from one to six (tables 1a,1b). Most often (27.7%), there were two caudate lobe veins usually one above the other in the left side of the IVC (table 8).

The presence of one or more right accessory hepatic veins draining the right lobe was observed in all the cases (tables 1a,1b). The left accessory hepatic veins were typically present, with the exception of one specimen. The presence of the intermediate accessory hepatic veins was more variable since only 66.6% of all specimens had them (table 1). The number of the veins draining the caudate lobe was higher than those draining the right lobe in 55.5% of the specimens, and the opposite was seen in 16.1%. The number of the right accessory veins was greater than that of left or intermediate accessory veins in 38.8% of the specimens.

In 72.2% of the specimens, the most inferior accessory vein was the inferior right accessory vein. In the remaining 27.7%, the most inferior was an intermediate accessory vein (table 9). The inferior right accessory veins were large and present in 16 of 18 specimens (tables 1a,1b). In the two exceptions, there were just superior right accessory veins. The trunks of some accessory veins were extrahepatic. This was observed only in the case of the inferior right accessory veins in 44.4% of the cases (8 specimens).

The diameter of the accessory veins was variable and no single pattern was observed. It ranged from 1.24mm to 1.8cm. The largest accessory vein was the inferior right accessory vein in 55.5% of the specimens (table 10). Amongst all specimens, the largest accessory vein was an inferior right vein with diameter of 1.8 cm, even larger than the main right hepatic vein found in this particular specimen (1.65cm).
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The right accessory veins, which drained the right lobe, tended to be larger while the left accessory veins, which drained the caudate lobe, tended to be smaller. Intermediate accessory veins which usually drain the lateral part of the caudate lobe, were larger than the left but usually smaller than the right, especially the inferior right accessory veins.

The length of the hepatic portion of the IVC was measured in 10 subjects where it was intact. In 60% of the specimens, the length was between 6 and 7cm (table 11).

Figure 14
Table 10: The largest accessory vein

<table>
<thead>
<tr>
<th>Largest accessory vein</th>
<th>Number of specimens</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inferior right accessory vein</td>
<td>10</td>
<td>55.5</td>
</tr>
<tr>
<td>Superior middle accessory vein</td>
<td>4</td>
<td>22.2</td>
</tr>
<tr>
<td>Superior right accessory vein</td>
<td>2</td>
<td>11.1</td>
</tr>
<tr>
<td>Superior left accessory vein</td>
<td>2</td>
<td>11.1</td>
</tr>
</tbody>
</table>

Figure 15
Table 11: The length of the hepatic segment of the IVC

<table>
<thead>
<tr>
<th>Length of the hepatic segment of the IVC</th>
<th>Number of specimens (total is 10 specimens)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-6 cm</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>6-7 cm</td>
<td>6</td>
<td>60</td>
</tr>
<tr>
<td>7-8 cm</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

DISCUSSION

Hepatic veins are intrahepatic veins which run in the substance of the liver and drain blood into the IVC. They are arranged in two groups, an upper group (the main hepatic veins) and a lower group (the accessory hepatic veins).

The main right hepatic vein (vena hepatica dextra) is located between the anterior and posterior segments of the right lobe, and drains the posterior segment and the superior area of the anterior segment of the right lobe (2,4). It is considered to be the largest of the three main hepatic veins (1,7). This was observed in this study since it was the largest in 77.7% of the specimens.

The main left hepatic vein (vena hepatica sinistra) is located in the lateral segment, which it drains in addition to the upper part of the medial segment (2,4). It was present in all the specimens of this study, and generally it was the second largest vein after the right hepatic vein.

The main middle hepatic vein (vena hepatica media) is situated between the right and the left lobes, and drains the lower part of the right anterior segment and the lower part of the medial segment (4). Commonly, it unites with the proper left hepatic vein in the liver to form a common trunk. When this occurs, there are only two main hepatic veins (1,4). This was observed in this study where 50% of the specimens had only two hepatic veins. This differs from some previous studies which reported the presence of 2 hepatic veins in 80% of the cases (1).

However, it was noted in this study that in 55.5% of the specimens which had three hepatic veins, the middle and the left hepatic veins opened into a well demarcated area. Therefore, the combined percentage of the cases which had two hepatic veins or where the middle and left hepatic veins opened into a well defined area was 77.7%. This is very similar to previous studies (1).

The accessory hepatic veins were quite variable in number, size and location. Previous studies reported a range of six to twenty veins (5). In this study, the number of the accessory veins ranged from one to thirteen.

The diameter of the accessory hepatic veins is usually smaller than that of the main hepatic veins (2). This was the case in this study where the diameter of the accessory veins ranged from 1.24mm to 1.8cm, which is smaller than that of the main hepatic veins which often vary between 9.5mm and 2.5cm.

Accessory hepatic veins are reported to drain either the right or caudate lobe (5). This was confirmed in this study, where it was found that the right accessory veins drain from the right lobe whereas the intermediate and left accessory veins drain from the caudate lobe.

It has been reported that there are one or more constant small hepatic veins that drain the caudate lobe (4). Usually there are two veins known as the venae hepaticae caudatae superior and inferior which drain into the left wall of the IVC (1). The findings of this study confirmed that and these veins were named the superior and inferior left accessory hepatic veins, and they were present in 94.4% of the cases (all the subjects except one). In addition, some of the specimens had as many as six accessory veins draining the caudate lobe.

This study also found that a variable number of accessory...
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veins (between one to five) opened in the right wall of IVC and drained the right lobe. These veins were divided into the superior and inferior right accessory veins, also known as the venae hepaticae posterolateralis (1). These veins were present in all the specimens. In addition, the right accessory veins tend to be larger than other accessory veins. Amongst them, an inferior right accessory vein, the vena hepatica posterior inferior (1), which drained the posterior right segment (to the right to the gall bladder). It is typically the largest accessory vein and the first entering on the right (2). This was confirmed in this study as the inferior right hepatic vein was the largest accessory vein in 66.6% of the cases. It was present in 88.8% of the cases, and in 50% of the specimens, it had extrahepatic trunks.

There was also another group of accessory hepatic veins named the superior and inferior intermediate accessory veins, also known as the venae hepaticae posterior intermediae and vena hepatica processi caudati that drain the caudate process (1). In this study, one or more intermediate hepatic veins were observed in 66.6% of the specimens, and they were located in the anterior wall of the hepatic segment of the IVC, directly below the main middle hepatic vein and between the right and left accessory veins. They drained the caudate lobe.

CONCLUSION

The role of the liver in the metabolic pathways is extremely important. Therefore, all the components of the liver are essential to its function. These components include the hepatic veins which drain the liver and constitute a major link between the portal and systemic circulation. Therefore, understanding the variation of these veins is of importance to medical treatment and surgical procedures involving the liver.

The importance of the hepatic veins and their vital role can be seen in the diseases and the disorders which result from their dysfunction. For instance, they may become stenotic or obstructed as in Budd-Chiari Syndrome. As blood cannot flow freely out of the liver, this leads to hepatomegaly, ascites and liver failure. (3).

The severity of the disease depends on the number of the hepatic veins affected by the occlusion. For instance, if the large main hepatic veins have been fully or partially obstructed, a dramatic drop in the flow of blood from the liver to the IVC will occur leading to the build up of a large quantity of blood in the portal circulation (portal hypertension) (3).

In this study, it was concluded that although there is much variation of the hepatic veins, some features tend to be constant. These include the number of main hepatic veins, the small size of the accessory hepatic veins, their location and the parts of the liver they drain.

Although the number of cases examined in this study was very limited, the findings were similar to results from previous studies reported in textbooks and carried out using a large number of specimens with different racial distribution.

References

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