Influence of Formation and Morphometry of the Inferior Vena Cava in the Use of Antithrombotic Devices

PETRU BORDEI[1], ELENA SAPTE[1], CORINA BURCUT[1], RAZVAN HAINAROSIE[2], RADU CRISTIAN JECAN[2,3,4], CRISTIAN CONSTANTIN POPA[2,5]*, VALERIU ARDELEANU[1,4,6,7]

[1] Ovidius University, Faculty of Medicine, 1 Universitatii Alley, 900470, Constanta, Romania
[2]Carol Davila University of Medicine and Pharmacy, 37 Dionisie Lupu, 020021, Bucharest, Romania
[3]Emergency Clinical Hospital Agrippa Ionescu, 7 Ion Mincu Str., 011356, Bucharest, Romania
[4]Arestetic Clinic, 78 Brailei Str., 800098, Galati, Romania
[5]University Emergency Hospital, 2nd Surgical Department, 169 Splaiul Independentei, 050098, Bucharest, Romania
[6] Dunarea de Jos University, Faculty of Medicine and Pharmacy, 47 Domneasca Str., 800008, Galati, Romania
[7]General Hospital CF, 5-7 Alexandru Moruzzi Str., 800223, Galati, Romania

The formation level of the inferior vena cava in the vertebral column was found to be at the level of L3 -L4 and L5 - S1, with differences between genders. The total length of the inferior vena cava ranged between 187.10 and 278.3 mm. Interiliac angle measured 48.40 and 85.80º. The length of the IVC from its formation point up to the termination of the right renal vein in the IVC ranged between 78.50 and 135.0mm, and the length of the IVC from its formation point to the termination of the left renal vein into the IVC ranged between 89.80 and 119.0mm. The length of the IVC from its formation up to the termination of the hepatic veins ranged between 197.20 and 263.70mm. The diameter of IVC at the point of its formation ranged between 18.0 and 26.20 mm, at the level of the right infrarenal level ranged between 20.10 and 28.70 mm, in 78.08% of the cases. In female cases, the diameter ranged between 18.06 and 25.69 mm, the diameter of the IVC at the level of the right suprarenal ranged between 19.82 and 31.09mm, the diameter at the level of the left infrarenal ranged between 18.59 and 32.49mm, at the level of the left suprarenal vein ranged between 19.10 and 33,80 mm, the diameter at the intrahepatic level ranged between 20.30 and 33.40mm, and the diameter of the IVC at the suprahepatic level ranged between 23.10 and 37.0mm.

Keywords: IVC -formation, morphometry, anti-thrombotic devices

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Also known as *ascending vena cava* [1,2], the inferior vena cava is formed on the right side of the lumbar vertebral column by joining unto a right angle both common iliac veins – right iliac vein and left iliac vein. After [3], its formation is located approximately 2,5cm to the right of the median plan, under the bifurcation of the aorta and posteriorly to the proximal portion of the right common iliac artery, longer by 7cm from the abdominal aorta. Its caliber increases the closer it gets to the heart due to its numerous tributaries. The IVC presents 2 dilations: one above the level of the terminations of the renal veins – the cav-renal sinus, and the other at the level of terminations of the hepatic veins – hepatic sinus of Calori [1,2,4]. The inferior vena cava is one of the most affected great vessel of the body in numerous malignant pathologies, such as right renal tumors or retroperitoneal tumors, by external compression or direct invasion [5-7].

Experimental part

Materials and methods

The study on the formation of the IVC and its morphometry was performed using a GE LightSpeed VCT64 Slice CT and a GE LightSpeed 16 Slice CT – both imagery machines within the Sf. Andrei County Clinical Hospital in Constanta. We have followed the formation level of the IVC along with the lumbar vertebral column and the value of the interiliac angle. From a morphometrical point of view, we have determined: the length of the vein from the formation point to its end into the right atrium, as well as the lengths of the IVC from its formation to the terminations of the right and left renal veins (taking into consideration that it's not often to find both on the same level), as well as the formation point of the IVC and the terminations fo the hepatic veins. The caliber of the IVC was measured at its formation point as well as at the caudal and cranial level of termination of the renal veins and liver veins. All measurements were made by gender and not all of the morphological targets could be studied in the same number of cases, each target being described on a typical number of cases.

Results and discussions

The formation of the IVC relative to the spine was studied in 54 of the cases, 19 males (35.19% of the cases) and 34 females (64.81% of the cases). We have discovered that the formation of the IVC ranged between L3-L4 spinal segment and L5-S1 disk segment (fig. 1).

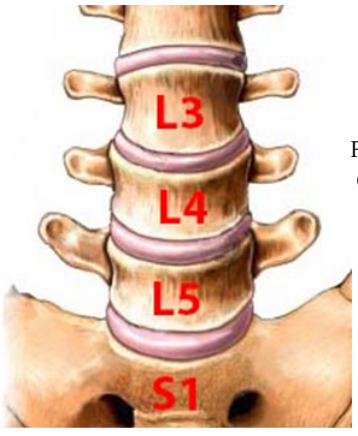

Fig. 1 The formation level of the IVC relative to the spine.

* email :cristianconstantinpopa@yahoo.com, Phone: +40744283763 *All authors with equal scientific contribution*

At the level of the L3-L4 segment, the IVC formed in 3 cases (5.56% of the cases), all male cases (15.79 of all male cases). In 30 cases (55.56% of the cases) the confluence of the two common iliac veins was at different levels of vertebra L4, 4 male cases (21.05% of male cases) and 26 female cases (74.29% of female cases):

-In 5 cases (9.26 % of the cases) the formation of the IVC formed at the level of the upper half of the body of the vertebra L4, 3 male cases (15.79% of the male cases) and 2 female cases (5.71% of the female cases). In 6 cases (11.11% of the cases) and all female cases (17.14% of female cases), the IVC formed at the middle of the body of the vertebra L4, and in19 cases (35.19% of the cases) the IVC formed at the lower body of the vertebra L4, in only one male case (5.26% of the male cases) and 18 female cases (51.43% of the female cases).

At the level of the L4 - L5 segment, the IVC formed in 10 cases (17.65% of the cases), all male cases (52.63% of the male cases). At the level of the L5 vertebra, 9 IVC were formed (16.67% of the cases) – all cases of the upper half of the vertebra, 2 male cases (10.53%) and 7 female cases (20%) (fig. 2). In 2 cases (3.7%), both female cases (5.71%) the IVC formed at the level of the L5 - S1 disks (fig. 2).

Fig. 2 Formation of the IVC at the upper margin of the L5 vertebra (female)

We measured the interiliac angle in 29 cases -15 female cases (51.71% of the total cases) and 14 male cases (42.28% of the total cases) -and it ranged between 48.40-85.80°. The most frequent met values were between 51.0-73.50°, i.e. in 79.31% of the total cases. In female cases, the interiliac angle had a value between 52.20-85.80°, the most frequent value being between 62.10-77.80° which represented 66.67% of female cases and 34.48% of the total cases (fig. 3). In male cases the interiliac value was between 48.4-74.70°, most frequently met values were between 48.4 - 55.40° which represented 92.86% of male cases and 44.83% of the total cases.

Fig. 3 Interiliac angle - 55.2°(female)

The total length of the inferior vena cava, at the level of its formation up to its termination in the right atrium was measured in 62 of the cases, 28 female cases (45.16%) and 34 male cases (54.84%), with values between 187.10 -270.30 mm, most frequently met values, in 41 cases (66.13%), were between 230.50 - 264.30 mm. In female cases the values were between 187.10% - 255.70mm, most frequently met values (in 82.15% of the female cases and 37.1% of the total cases) of 208.70% - 242.70mm. In male cases, the total length of the inferior vena cava was between 215.40 -278.30 mm, most frequently values were between 230.50 -264.30 mm (in 73.53% of the male cases and 40.32% of the total cases) (fig. 4).

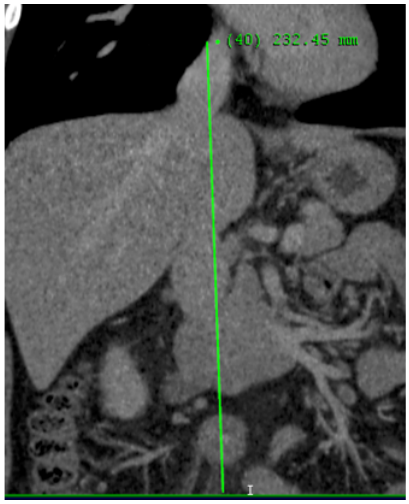

Fig. 4. Total length of the IVC -232.45mm (male)

The length of the IVC from its formation level up to the termination into the right renal vein into the vena cava was measured in 35 of the cases, 14 female cases (40% of the total cases) and 21 male cases (60% of the total cases). The values were between 78.50 -135 mm, most frequently met values (in 74.29% of the total cases) were between 90.20 -108.20mm. In female cases, the length range was between 78.50 - 106.8 mm, most frequently values were between 90.20 - 106.8 mm (78.57% of the female cases and 31.43% of the total cases). In male cases, the length range was between 90.20 - 106.8 mm (in 95.24% of the male cases and 57.14% of the total cases) (fig. 5).

Fig. 5. The length of the IVC from its formation and the right renal vein-12.09mm (male)

In 36 cases we measured *the length of the IVC from its formation level up to the termination into the left renal vein into the vena cava*. 15 female cases (41.67% of the total cases) and 21 male cases (58.33% of the total cases), with a range between 89.80 - 119.0 mm, most frequently met values were between 92.0 - 119mm (in 74.44% of the cases). In female cases, the length range was between 89.90 - 101.2 mm, most frequently met values were between 92.0 - 101.2mm (in 86.67% of the female cases and 36.11% of the total cases). In male cases, the length range was between 95.80 - 119.0 mm, most frequently met values were between 100.20 - 119.0 mm (in 85.71% of the male cases and 50% of the total cases).

In 34 cases we measured *the length of the IVC from its formation up to the termination of the hepatic veins into the IVC*, 17 cases for each gender, with ranges between 197.20 - 263.70mm. In female cases, the range was between 167.70 - 101.2 mm, most frequently met cases

with a range of 167.70 - 233.6mm (in 88.24% of female cases and 44.12% of the total cases). In male cases the length range was between 172.20 - 262.70mm, most frequently met values ranged between 217.20 -263.70mm (in 94.12% of the male cases and 46.06% of the total cases).

In 51 cases we measured *the diameter of the IVC at the level of its formation*, 29 female cases (56.86% of the total cases) and 22 male cases (43.14% of the total cases). The diameter range was between 18.0 - 26.20mm, most frequently met values were between 20.21 - 26.20mm in 96.08% of the total cases. In female cases, the diameter range was between 18.0 - 25.69mm, most frequently ranges were between 20.21 - 23.90mm (in 89.66% of the female cases). In male cases, the diameter range was between 19.50 - 26.20mm, most frequently met values were between 23.1 - 26.2mm (94.45% of the male cases).

The diameter of the IVC at the right infrarenal level was measured in 52 cases, 29 female cases (55.77% of the total cases) and 22 male cases (44.23% of the total cases), with range values between 17.60 - 30.10mm, most frequently met values were between 20.10 - 28.70mm (78.08 of the cases). In female cases, the diameter range values were between 19.67- 28.10mm (86.21% of the female cases). In male cases, the diameter range values were between 19.50 - 29.20mm, most frequently met values were between 20.10 - 28.70mm (86.96% of the male cases).

The diameter of the IVC at the right suprarenal level was measured in 48 cases, 25 female cases (52.08% of the total cases) and 23 male cases (47.92% of the total cases), with range values between 21.03 - 64.70 mm in 93.75% of the total cases. In female cases, the diameter range values were between 21.42 - 31.03mm, most frequently met values were between 21.42 - 29.64 mm (96% of all female cases) (fig. 6). In male cases, the diameter range values were between 21.03 - 31.09mm, most frequently met values were between 21.03 - 29.10mm (91.31% of the male cases).

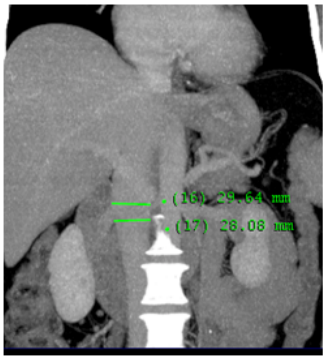

Fig. 6. The right infrarenal diameter of the vena cava – 28.08mm, smaller than the suprarenal diameter (29.64mm) corresponding to 1.56mm (female)

The diameter of the IVC at the left infrarenal level was measured in 46 cases, 25 female cases (54.35% of the cases) and 21 male cases (45.56% of the cases), with range values between 18.59 - 32.49mm, most frequently met within the range values between 20.60 - 28.85mm (78.08% of the cases). In female cases, the diameter values ranged between 19.67 - 24.10mm (in 92 of the female cases) (fig. 7). In male cases, the diameter ranged between 19.99-32.49mm, most frequently met values ranged between 23.02 - 32.49mm (99% of the male cases).

The diameter of the IVC at the intrahepatic level was measured in 33 cases, 17 female cases (51.52% of the cases) and 16 male cases (48.48% of the cases), with range values between 20.30 - 33.40 mm. In female cases, the diameter values ranged between 20.30 - 25.80 mm and in male cases, the diameter ranged between 24.73 - 33.40 mm (fig. 8).

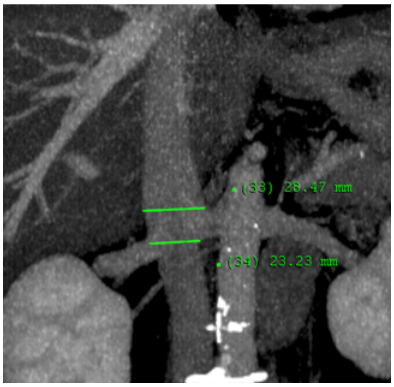

Fig. 7.The left infrarenal diameter of the vena cava = 23.23mm, smaller that the suprarenal diameter (28.47mm), corresponding to 5.24mm (female)

Fig. 8. Intrahepatic cava diameter = 29.67mm (male)

The diameter of the IVC at the suprahepatic level was measured in 47 cases, 23 female cases (48.94% of the cases) and 24 male cases (51.06% of the cases), with values ranges 23.10 - 37.0 mm, most frequent values ranged between 23.10 - 35.30mm (in 80.43% of the cases). In female cases, the diameter values ranged between 23.93 - 34.31 mm, most frequently met values ranged between 23.93 - 29.75 mm (in 95.65% of the female cases) (fig. 9). In male cases, the diameter values ranged between 23.10 - 37.0mm.

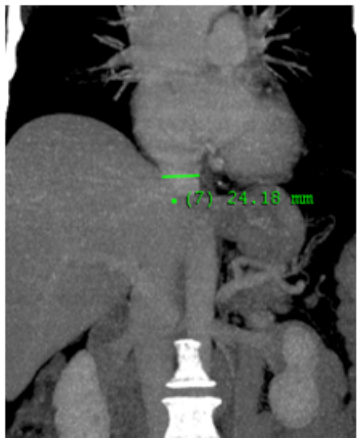

Fig. 9. Suprahepatic cava diameter = 24.18mm (female)

By comparing our results to the ones that already exist in the anatomy treaties related to the level of formation of the IVC relative to the vertebral column, it results that we have met cases on the formation of the IVC with wider range of values (L3-L4 spinal segment, L5-S1 disks). In the specialist literature, the formation of the IVC is found at the level of the L4-L5 segment [1,2,8], at the upper part of the vertebra L5 [4,9,10], at the level of the L5 vertebra, without any other clarifications [3,11]. The authors in the specialist literature we have consulted, do not specify the level of formation of the IVC divided by gender. The same study, in the same area, conducted approximate 5 years previously, on a smaller number of cases [12], places the formation of the IVC at the L4-L5 spinal segment, in the upper half of the body of the vertebra L5, and in a study performed only the previous year, find the formation of the IVC in the range between lower half of L5- lower half of L4 [13[.

Table 1

COMPARISON RELATED TO LEVEL OF FORMATION OF THE IVC RELATIVE TO THE VERTEBRAL COLUMN BETWEEN THE STUDY OF [11] AND OUR STUDY

Vertebral level	Piro	Cases
L3 – L4 disk	-	5.56%
L4	12%	55.93%
L4 – L5 disk	2%	18.52%
L5	64%	16.67%
L5 – S1 disk	12%	3,70%
S1	10%	-

There was only one author that detailed the level of formation of the IVC relative to the vertebral column (table 1). By comparing both studies, we not that [14] did not discover any case with *high* vena cava formation (L3 – L4 spinal segment) and we have not discovered any case with *low* vena cava formation (S1 vertebra). In addition, in the study of [14], in the majority of cases, the formation of the vena cava was at the level of the L5 vertebra, whereas our study indicates the formation at the level of the L4 vertebra. [14] does not specify the level of formation at vertebral bodies and does not specify in percentage the formation of the vena cava divided by gender. [15] considers the formation of the inferior vena cava within the range of the caudal portion of the L3 vertebra -cranial part S1-in female cases the range was caudal L3 -cranial vertebra S1, whereas in male cases, the range was between cranial vertebras L4, L5 - S1disks. We have determined that in male cases, the IVC formed within the range of the L3 -L4 disks and the upper margin of L5 and in female cases, within the range of the upper half of L4 -L5-S1 disk.

Kawahara [quoted by 14] considers the formation of the IVC within the range of the L4-L5 disks in 95% of the cases, whereas [16,17] and Vraney & Kawahara [quoted by 14] places the formation of the IVC at the level of L4 vertebra, ranging from 4 to 21% of the cases and rarely at the level of the L5 -S1 disks.

We measured *the sub-cava angle* with values ranging between între 48.4-85.8°, whereas [1,2] found it within the range value of 60-65°, [14] using anatomical methods, measured it within the value range between 69+/-21° (values between 21-107°). [16] using the same anatomical methods, measured it within the range of 73+/-17° (with values between 35-115°). [17] found the angle to be within the range 75+/-21°, (with values between 28-107°), [12] found it within the range value of 23.4-78.7°, and [13] found it within the range values between 51,0-84,2°. In male cases, the angle was ranged between 51.0-74.7°, whereas for female cases the range was between 55.2-84.2°. In our measurements we have always found an acute sub-cava angle, in female cases the minimum value being wider by 4.20mm than in male cases, whereas for max. value, by 9.5mm.

The total length of the IVC was longer by 28.3mm in male cases (minimum value) and by 32.40mm (maximum value). The minimum value of the length in our study is shorter by 14.9mm than the value given in [1,2,9] and 12.9mm shorter than the value given by [4], being longer by 7.1mm than the value given in [8].

The maximum value we encountered is higher than all authors quoted, 44.0 mm longer than the maximum value given by [1,2], 74.0 mm versus [9], 94.0 mm from the given value of [4] and the maximum value given by [8].

In theese cases, in male cases the value was bigger by 28.30mm than the minimum value, and for the maximum value was bigger by 22.60mm.

As the right and left renal veins are frequently located at different levels [18] with respect to each other, the length of the IVC from its origin to the end of the renal vein was measured separately for each renal vein.

The length of the IVC from its origin to the termination of the right renal vein into the vena cava had a lower value in the female cases than in the male cases, by 11.90mm, and also, the maximum value was lower by 33.7mm (max. value of 135mm was met in a single male case). By dissection, [19] found that the length of the IVC in the infrarenal section had an average length of 96mm, value close to the one we have measured for female gender cases (90.20-98.80 mm in 42.86% of the female cases and 17.14% of the total cases) but smaller than the value met in the male cases-in only 28.57% of the male cases (17.14% of the total cases) with a length of 80.40- 99.50mm.

The length of the IVC from its origin to the termination of the left renal vein into the IVC, the minimum value had a smaller value in the female cases than in the male cases by 11.90mm, and also the maximum value was smaller by 7.80mm.

The length of the IVC from its origin to the termination of the hepatic veins was measured in relation to the right hepatic vein because the right and left hepatic veins most frequently terminate at the same level in the IVC. The minimum value for the IVC was longer by 4.50mm in male cases than in the female cases, however, the lowest value (172.2mm) was registered in a single male case. The maximum value of the length of the IVC from its origin to the termination of the hepatic veins was longer by 16.20mm in male cases than female cases.

The caliber of the IVC was measured on 5 levels: the origin, infrarenal and right suprarenal left suprarenal, infrahepatic and suprahepatic.

At the level of its formation, the IVC had an average caliber of 20mm [1,2], and according to [4], the IVC is averagely of 22mm caliber. We have found that at the origin of the IVC, the minimum value as well as the maximum value is bigger in the male cases, by 0.15mm for the minimum value and by 0.60mm for the maximum value. The maximum value (25.6mm) of the caliber was met in 2 female cases and the following value was of 23.9mm- the difference from this value and the maximum value of the diameter in the male cases being of 2.30mm.

At the right infrarenal level, the minimum value of the caliber of the IVC was bigger in female cases than in male cases by 0.46mm, but taking into consideration that the minimum value (17.6 mm) was met in only 1 case, the following values being 19.5mm and respectively 23.1 mm, the minimum value was bigger by 1.44mm in male cases, respectively 5.04mm. The maximum value of the diameter at the right infrarenal was bigger by 1.95mm in male cases than in female cases, the maximum value (28.06mm in female cases, respectively 30.10mm in male cases) was met in only 1 case for each gender.

At the right suprarenal level, the minimum value of the caliber of the IVC in female cases is bigger by 1.60mm than in male cases, only one case with the minimum value (19,82mm) was met in the male cases. The maximum value of the right suprarenal cava diameter was bigger in the male cases by just 0.06mm, the maximum values for both genders (31.03mm for female cases, respectively 31.09mm on male cases) was met in only 1 case per gender.

In 48 cases we have made comparative measurements of the infrarenal and suprarenal diameters on the same subjects, to asses that the suprarenal diamater was bigger by a range of 0.10 -8.54mm, most frequently met difference being from 1.58-2.97mm in 62.50% of the cases, respectively the difference of 8,54mm was met in only 1 case. In female cases the difference most frequently met was between 1.58- 2.97mm (in 73.08% of the cases) and in male cases, between 1.80-2.50mm (in 50% of the cases).

At the left infrarenal level, the minimun value of the IVC was bigger in male cases by 1.45mm than in the female cases, on both genders the minimum value being met in only 1 case. The maximum value of the diameter at the left infrarenal level was bigger in male cases by 3.64mm than in female cases, the maximum value of 28.85mm was met in only one female case.

At the left suprarenal level, the minimum value for the caliber of the IVC was bigger by 4.70mm in the male cases than the female cases, the minimum values on both gender cases were met only once per gender case, the following values being 21.40mm in female cases, respectively 23.80mm in male cases. The maximum value of the left suprarenal cava diamater was bigger by only 2.44mm in male cases, maximum value of 31.36mm was met in only 1 female case.

In 47 cases we have made comparative measurements of the infrarenal and suprarenal diameters on the same subjects, to asses that the suprarenal diamater was bigger by a range of 0.78 - 6.44mm, most frequently difference being from 2.50 - 5.24mm (in 72.34% of the cases). In female cases the most frequently met differencies were between 2.60 - 5.24mm (84.61% of the cases), whereas in male cases, the differencies were of various values, with a range starting from 0.8 - 6.66mm and from 2.50 -4.50mm (in 48.08% of the cases), and from 6.30 -6.44mm (in 19.05% of the male cases).

[1,2] measured the vena cava at its middle level (infrarenal) assessing a value of 24-26mm, [19] performed measurement of 100 fresh cadavers and found that the real diameter in the middle infrarenal part of the IVC is 17mm, [8] establishes that the average diameter is 24mm (range values between 17-35mm on 20 fresh cadavers). [20], using the method of measurement with a calibrated intravascular catheter, considers the average diameter of the infrarenal cava vein to be of 21 mm+/-3.7, and [21] establishes the average diameter to be of 21.3mm with range values from 10 - 31mm. [22] considers the average diamater of the infrarenal cava vein to be 20mm, with range values between 15-30mm.

In some cases, approximatively 5cm above the formation of the IVC, we have met a decrease in the diameter of the IVC up to 0.02- 4.20mm in female cases, respectively 0.91-6.30mm in male cases (maximum value being met in 1 single case), only to discover that at the infrarenal level it surpasses the diameter at its formation, as we previously presented. This would suggest that, at its formation, the IVC presents with a dilation that would be added to the other classical two, the renal and hepatic one.

The cava diameter *at intrahepatic level* presented with a value much higher than the minimum value for the male cases, by 3.13mm than female cases, and the maximum value was higher by 7.60mm in male cases.

At suprahepatic level, the vein diameter had a higher minimum value in female cases, by 0.83mm than in male cases, the maximum value being higher by 2.69mm in males cases than in female cases (maximum values being met only in 1 case per gender case).

In 34 cases we have made comparative measurements of the intrahepatic and suprahepatic diameters on the same subjects, assessing that the suprahepatic diameter was bigger by 0.39 - 9.40mm, most frequently met difference, in 76.47% of the cases, was between 3.56-5.82mm. In female cases, the most frequent difference ranged from 3.56 -5.30mm (87.50% of the cases) whereas in male cases, the most frequent differencies ranged between 4.20 -5.82mm (in 66.67% of the male cases).

[23] considers the value of the retrocaval diameter (infrahepatic) of 23 mm, with a range value of 15-30mm.

[20] considers as megacava the IVCs that exceed 28mm diameter, with a frequency ranged between 2-12%, [21] considers as megacava the veins that exceed a 30mm diameter (met in 10% of the cases) and Dutta (quotted by 21) finds them in 12% of the cases. We have found 31 cases where the IVCs had a value range between 28.3-37.0mm, which represents approximatively 10.88% of the cases, 13 female cases (8.61%) and 18 male cases (13.43%).

Conclusions

The IVC morphometry, especially its diameter at different levels in relation to the termination of its greater affluents [24], is of particular importance in grafting or implantation of anti-thrombotic devices, and according to [19,22,25] the infrarenal segment occupies a selective place. This demostrates the importance of the cavography before implementation in order to determinate the real diameter of the IVC before placing the filter and preventing the migration of the implanted filters [20]. Thereof, it results the importance of the measurement methods of the venous diameter [according to 22]. At present, there are 6 types of determining the diameter of the IVC: anatomically, sonographically, radiologically (after placing the filter), cavographically, CT scan and MRI. [22] considers that anatomical, radiological and sonographical methods are subjective, hence considered doubtful and in his opinion the CT scan is the better choice in measuring different diameters of the IVC.

According to [20], the use of calibrated intravascular catheter is the most precise method to measure the diameter of the IVC.

There are differencies in the results we have obtained and the specialist literature, maily due to the number of cases and the period of time for the study. Many authors consider the statistical differencies on the geographical area where the study was performed, but differencies are influenced also by gender, age and mostly the methods used to get the results. There are differencies when the morphometry is performed on formalized cadavers, fresh cadavers or by injecting plastics, considering that more accurate results would be obtained by CT scans or echographically, but even in such cases there might be discrepancies based on the incidence and on the level of expertise of the examiner.

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