Anatomic bases of medical, radiological and surgical techniques

Anatomy of the common trunk of the middle and left hepatic veins: application to liver transplantation

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Abstract

An anastomosis between the common trunk of the middle and left hepatic veins of the receiver and the cranial portion of the inferior vena cava of the donor is one of the techniques for restoration of hepato-caval continuity in orthotopic liver transplantation. This technique avoids dissection of the retrohepatic vena cava and total caval clamping. The aim of this study was to define the feasibility of this technique by a morphologic and biometric study of the common trunk of the middle and left hepatic veins on the basis of 64 injection-corrosion hepatic specimens and 21 fresh subjects. A common trunk for the middle and left hepatic veins was present in 54 of 64 cases (84%) with a length of 3 to 17 mm. The diameter of the new ostium constructed by section 0.5 cm proximal to the junction of the middle and left hepatic veins was 23.9 ± 2.3 mm, which approximated to that of the vena cava where it traversed the diaphragm (24.4 ± 2.0 mm). These findings confirmed that restoration of hepato-caval continuity by anastomosis between the common trunk of the middle and left hepatic veins of the receiver and the cranial portion of the vena cava of the graft is possible without incongruence. This study makes no assumptions about the hemodynamic effects associated with the smallest diameter of the true ostium of the common trunk at its opening into the inferior vena cava. In this study, the morphology of the common trunk was comparable to that observed by Nakamura. Further, we propose an anatomo-clinical classification allowing evaluation of the facility of vascular control of the common trunk in terms of the number and location of the collateral veins.

Restoration of hepato-caval venous continuity is an essential stage in orthotopic liver transplantation. Among the different techniques for restoration, preservation of the retrohepatic inferior vena cava (IVC) of the receiver [2, 3, 5, 14, 17, 18], described by Calne [5] and then under the name of "piggy-back" by Tzakis et al [17, 18], allows avoidance of the hemorrhagic stage [2, 14, 18] of retrocaval dissection and resection of the inferior vena cava (IVC), especially in cirrhotic patients [9]. Since then, several techniques for preserving the IVC have been described [2, 3, 14]. Some of these allow maintenance of the caval flow during construction of the anastomosis while avoiding total caval clamping [5, 14, 17, 18]. The preservation of caval flow ensures the hemodynamic stability of the patient [17, 17] and reduces the need for an extracorporeal shunt [2, 17] with its intrinsic complications [16]. One of these techniques, derived from the "piggy-back" of Tzakis, consists of anastomosing the cranial extremity of the retrohepatic IVC of the graft [14, 17, 18] with the common trunk of the middle and left hepatic vv. of the receiver (Fig. 1). The performance of this anastomosis requires favorable anatomic conditions [18]. The aim of this study was to assess the feasibility of this technique by a morphologic and biometric study of the common trunk in the livers of fresh subjects.

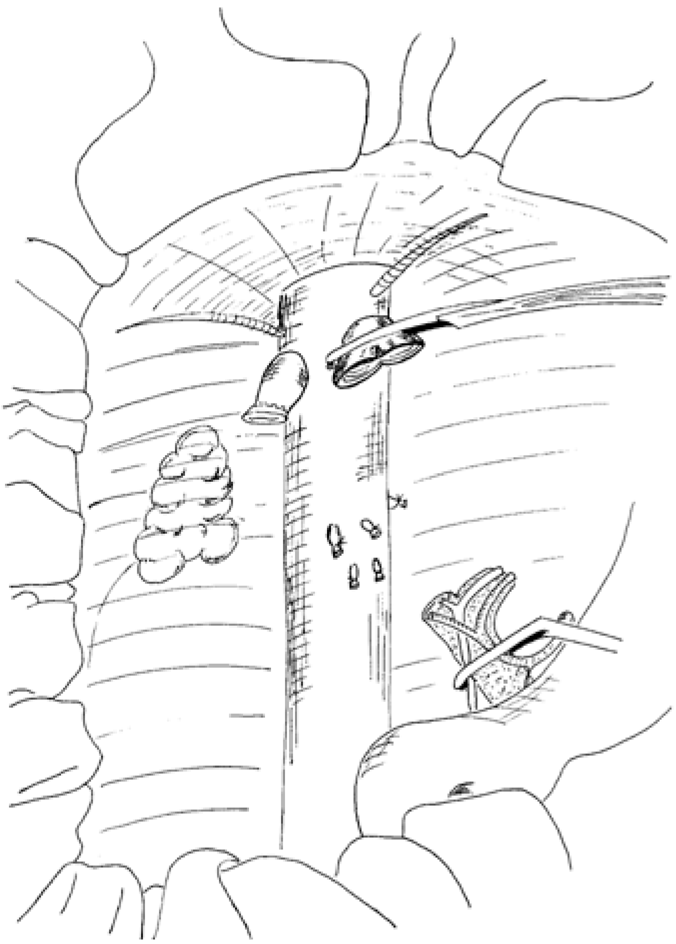


Fig. 1
Frontal view of right subphrenic region. A total hepatectomy has been performed with preservation of the vena cava. The right hepatic v. has been ligated. The common trunk has been sectioned to receive the cranial extremity of the vena cava of the receiver. The clamp is placed on the common trunk, allowing preservation of caval flow during construction of the anastomosis

Material and methods

This study consisted of two parts: an anatomic study of the morphology of the common trunk by injection-corrosion in the explanted liver and a biometric study in situ of the hepatic vv. and of the IVC where it traversed the diaphragm in fresh human subjects.

Morphologic study of the common trunk of the middle and left hepatic vv.

The morphology of the middle and left hepatic vv. was studied in 64 livers of fresh subjects by the technique of injection-corrosion [9]. The resin was injected into the infrahepatic vena cava after ligation of the suprahepatic IVC at the level of the right atrium. The vascular sys-tem was irrigated with normal saline at 37° C and then injected with a mixture of polyester resin (Ambrex R®), an accelerator (OCTOAC of cobalt®) and a catalyst (butamox®) with a dye for polyester resin (RAC®). After corrosion in hydrochloric acid, the cast of the vessels allowed study of the arrangement of the middle and left hepatic vv., measurement of the frequency of a common trunk and its length, and noting the pattern of the collateral vv. The middle and left hepatic vv. were distributed according to the classification of Nakamura [15] (Fig. 2). The 64 livers were then classified into four groups, using a new anatomo-surgical classification that allows for the presence or absence of a common trunk and for the number and location of the collateral branches.

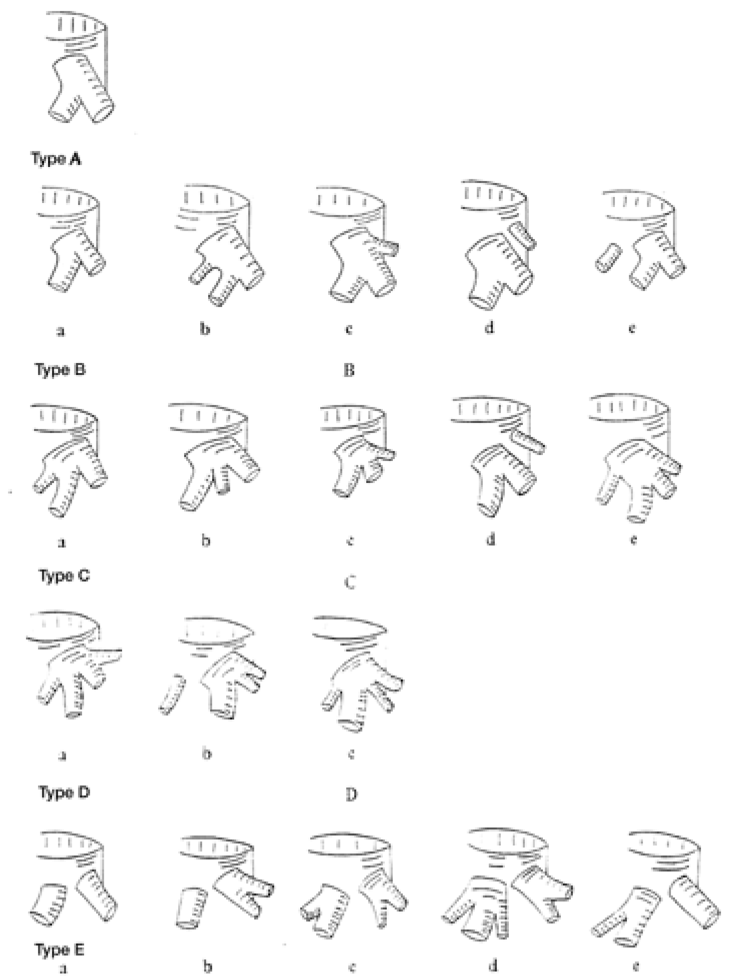


Fig. 2
Termination of middle and left hepatic vv.: classification of Nakamura. This classification is based on the branching of the middle and left hepatic vv. less than 1 cm from the IVC. It allows for branches emptying either directly into the IVC or into the last cm of the common trunk. When the common trunk measures less than 1 cm, the middle and left hepatic vv. each count as one branch. Type A includes common trunks of 1 cm or over which do not receive a branch in the last cm. Type B includes common trunks associated with two branches less than 1 cm from the IVC, ie, short trunks, or trunks of over 1 cm associated with one branch. Type C includes common trunks having three branches less than 1 cm from the IVC and Type D has four branches at less than 1 cm. Type E includes cases where no common trunk exists. The subgroups of this classification are listed in terms of the presence and position of the middle and left hepatic vv. and of the vv. of Couinaud's segments 2,4 and 8 [10,15] (Fig. 5). The right anterosuperior v. or v. of Couinaud's segment 8 is present in subgroups Bb, Be, Ca, Da, Db, Dc, Ec, Ed, Ee. The left superior v. drains segment 2 and is present in subgroups Bc, Bd, Cb, C d, Ce, Db, Dc, Eb. The left medial v. or v. of segment 4 [10] is present in subgroups Cc, Da, Ec, Ed

Biometric study of the hepatic vv. and the IVC

The biometry of the hepatic vv. and the IVC was studied by measurement with a bougie calibrated on 21 livers in situ. Figure 3 shows the different types of measurements made. The length of the common trunk was measured between the junction of the middle and left hepatic vv. and the ostium of this trunk in the IVC. The diameter of the IVC was measured at its passage through the diaphragm. A new ostium of the common trunk was artificially created by section 0.5 cm proximal to the junction of the middle and left hepatic vv.

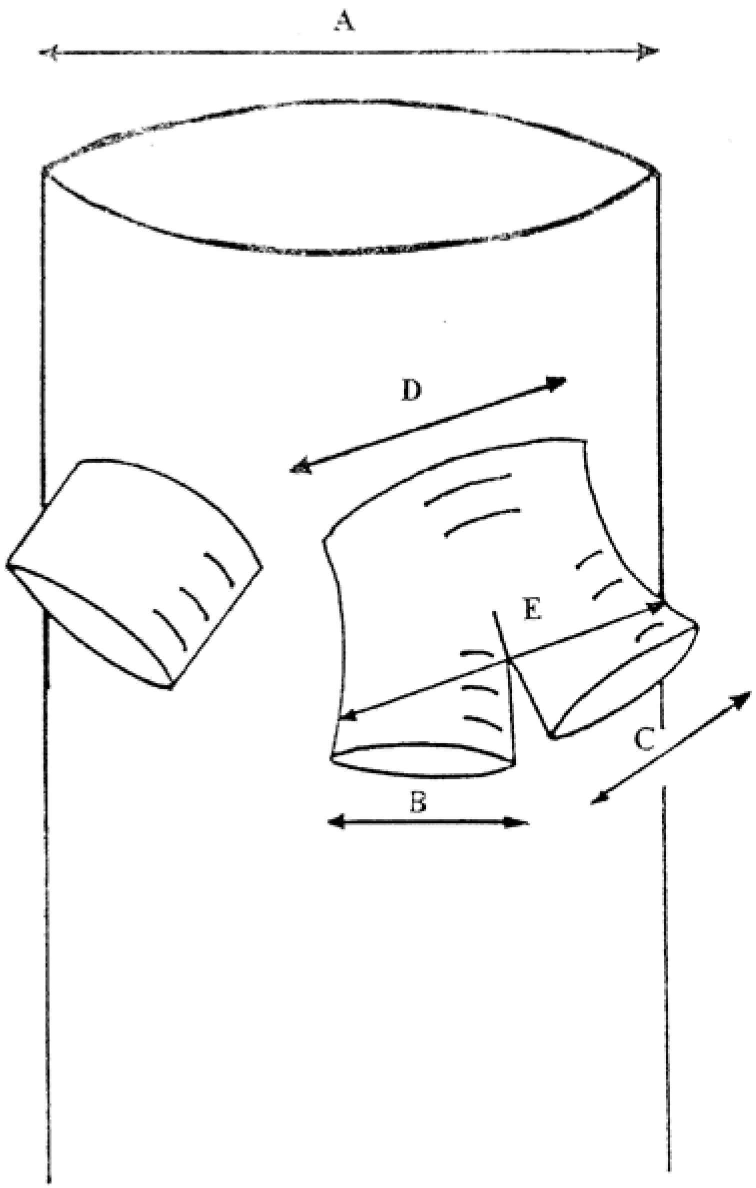


Fig. 3
Diagram of measurements made in 21 fresh subjects. *A* diameter of suprahepatic IVC at its diaphragmatic passage; *B*, diameter of middle hepatic v.; *C*, diameter of left hepatic v.; *D*, diameter of ostium of common trunk; *E,* diameter of new ostium created by section 0.5 cm proximal to confluence of middle and left hepatic vv.

Results

Morphologic study of the common trunk of the middle and left hepatic vv.

A common trunk was present in 54 of the 64 cases (84%) The results of the morphologic study are given in Table 1 (Fig. 4a-e). There was no significant difference between the distribution observed in this series and that of Nakamura [15]. The length of the common trunk varied between 3 and 17 mm. Table 2 shows the distribution of the cases as regards the presence or absence of a common trunk and the existence of branches emptying less than 1 cm from the opening of the common trunk or directly into the IVC. On the basis of these criteria, four groups were defined with increasing difficulty of vascular control.

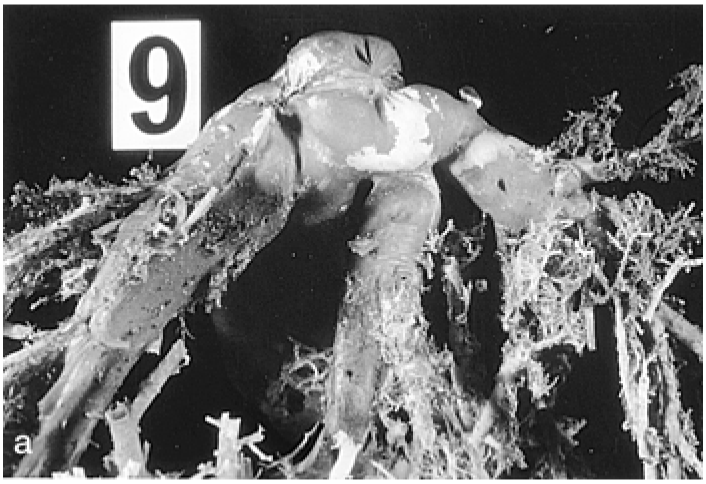
	Wind et al	Nakamura et al
Type	No. of cases (%)	No. of cases (%)
A	6 (9.4)	9 (10.84)
B	25 (39.06)	35 (42.17)
C	16 (25)	22 (26.51)
D	7 (10.94)	4 (4.82)
E	10 (15.6)	13 (15.66)

Chi2 for the groups: NS

Table 1. Classification of 64 injection-corrosion specimens in terms of the morphology of the middle and left hepatic vv.: comparison with the study of Nakamura in 83 livers

Type	Morphologic criteria	Percentage (no. of cases)
I	No branch less than 1 cm from the entry of the common trunk into the IVC. No branch emptying directly into the IVC	32.81 (21)
II	One or more branches less than 1 cm from the ostium of the common trunk except for branches opening directly into the IVC	43.785 (28)
III	One or more branches emptying directly into the IVC whatever the morphology of the common trunk	7.81 (5)
IV	No common trunk	15.63 (10)

Table 2. Anatomo-clinical classification of the morphology of the common trunk of the middle and left hepatic vv.



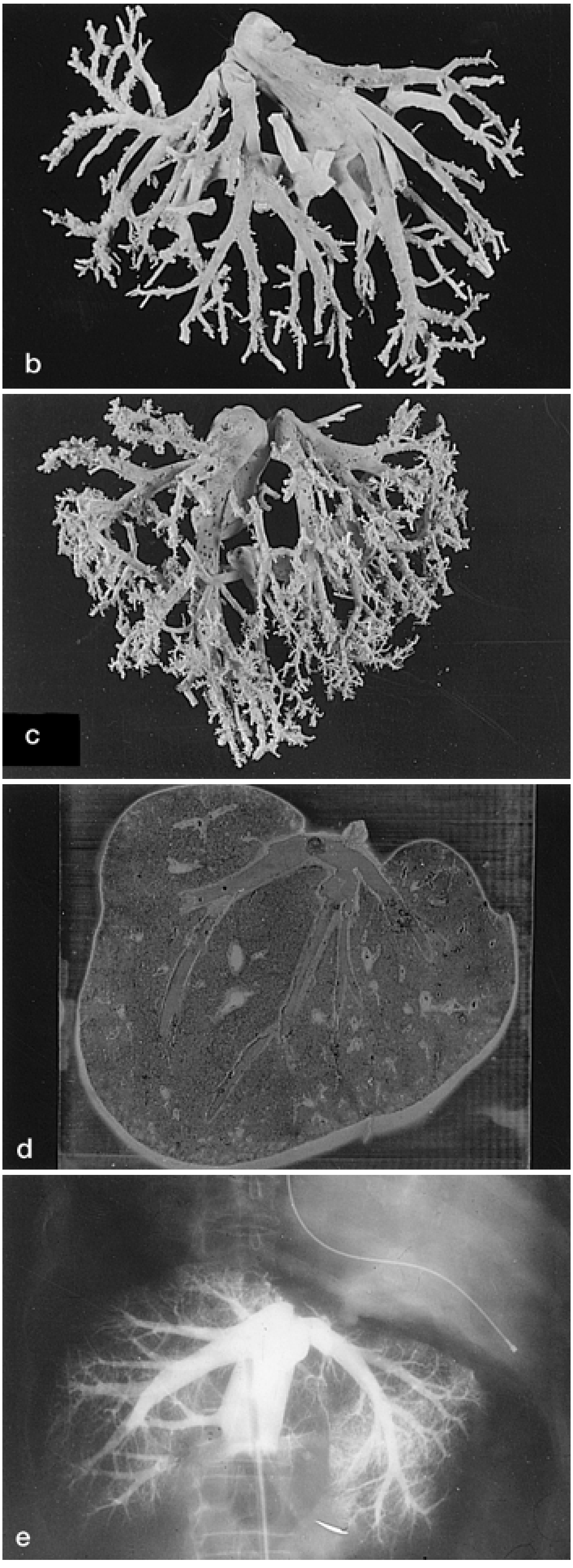

b
c
d
e

Fig. 4a-e
a-c Casts of hepatic vv. obtained after injection-corrosion. **c** There is a collateral branch from segment 2 which empties into the common trunk. **d** Section of injected liver passing through cavo-suprahepatic confluence. **e** Opacification of hepatic venous system after ligation of suprahepatic IVC. There is a collateral of segment 2 on the common trunk

Biometry of the hepatic vv. and the IVC

The results are given in Table 3. The length of the common trunk varied from 3 to 7 mm. The diameter of the new ostium created by section at 5 cm proximal to the junction of the middle and left hepatic vv. was 23.9 ±2.3 mm. That of the IVC at its diaphragmatic passage was 24.4 ± 2. However, the diameter of the actual ostium of the common trunk at its termination in the IVC was 13.6 ± 1.9 mm.

Diameter measured	Diameter ± SD (mm)
Inferior vena cava	24.4 ± 2.0
Middle hepatic v.	8.7 ± 1.8
Left hepatic v.	8.6 ± 2.0
Ostium of common trunk	13.6 ± 1.9
New ostium of common trunk	23.8 ± 2.3

Table 3. Measurements made in 21 fresh subjects having a common trunk Discussion

This study allowed evaluation of the anatomic parameters necessary for construction of the anastomosis between the cranial extremity of the IVC of the graft and the common trunk of the middle and left hepatic vv. of the receiver in liver transplantation in the adult. A common trunk was present in the majority of cases and the creation of a new ostium by section of the middle and left hepatic vv. proximal to their junction made it possible to obtain a diameter close to that of the IVC at its diaphragmatic passage. Thus, from these findings it is possible to construct this anastomosis without any incongruence. Furthermore, with this technique the anastomosis is possible while using isolated clamping of the common trunk or lateral clamping of the IVC, thus preserving partial caval flow.

A common trunk for the middle and left hepatic vv. is present in 62 to 97% of cases [4, 6, 7, 10, 11, 12, 15] with a mean length of 10 mm. Several classifications based on the morphology of the common trunk have been described. Masselot and Leborgne [12] proposed a simple classification into 3 types based solely on the length of the common trunk (common trunk short, long or absent). This classification is not sufficient to systematize all the varieties of common trunk that exist. Nakamura [15] described a classification based on the branching of the middle and left hepatic vv. less than 1 cm from the IVC. Indeed, for this author 1 cm is the minimum length allowing control of the vein. He also takes into account the branches which open either directly into the IVC or into the last cm of the common trunk. When the common trunk measures less than 1 cm, the middle and left hepatic vv. each count as one branch. Type A includes common trunks of 1 cm or more not receiving a branch in its last cm. Type B includes common trunks combined with two branches less than 1 cm from the IVC, ie, short trunks or trunks of over 1 cm associated with a branch. Type C includes common trunks having three branches less than 1 cm from the IVC, and type D has four branches less than 1 cm away. Type E includes cases where there is no common trunk present. The subgroups of this classification are listed in terms of the presence and position of the middle and left hepatic vv. and of the vv. of segments 2, 4 and 8 of Couinaud [10, 15] (Fig. 5). The right anterosuperior v. or v. of segment 8 of Couinaud is an affluent of the middle v. and travels on its right in the modal description [10, 15]. The left superior v. drains Couinaud's segment 2 and travels near the posterior border of the liver not far from the outflow of the left hepatic v., into which it empties in the modal description [10, 15]. The left medial v. of vein of Couinaud's segment 4 travels between the middle and left hepatic vv. [10, 15] and empties into the sagittal v.

in the modal account of Couinaud [10]. It emerges from this classification [10] that these vv. empty either directly into the IVC or into the last cm of the common trunk or of one of its branches in 39% of cases for the v. of segment 8, 28% of cases for the v. draining segment 7, and 12.5% for the v. of segment 4. A common trunk of at least one cm, without a collateral branch in this portion, existed in only 10% of cases of Nakamura's series and in 9.4% of cases in our own series. The factors required for assessment of the feasibility of vascular control of the common trunk are the existence of a common trunk, its length, and the presence of collateral branches emptying either into this trunk or its branches or into the IVC. We propose a simplified classification into four types based on these factors, the feasibility of vascular control being directly linked to the stage of classification (Table 2). This technique is therefore practicable when-ever a common trunk is present, ie, in 84.4% of cases in our series and 84.34% in that of Nakamura [15]. The absence of a common trunk means that one must resort to other "piggy-back" techniques [2, 3].

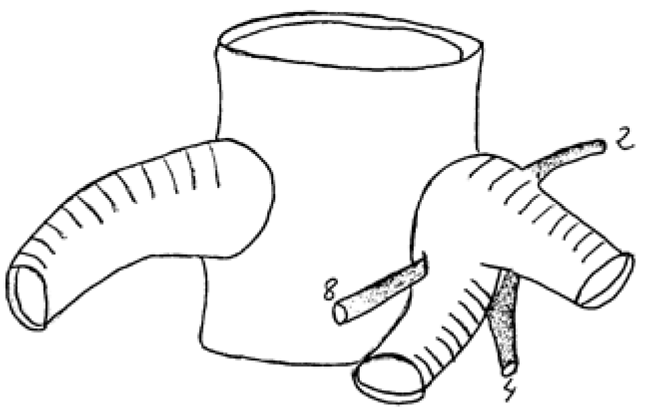


Fig. 5
Diagram representing the vv. of segments *2, 4* and *8* of Couinaud at their opening into the IVC

Calne and Williams were the first to retain the IVC of the receiver and to anastomose the ostium of one of the hepatic vv. to the cranial portion of the IVC of the graft [5]. Tzakis et al suggested the construction of a new ostium by destroying the septa between the two or usually three hepatic vv. [17, 18]. Belghiti et al [2] proposed a side-to-side anastomosis between the IVC of the donor and that of the receiver. Meunier et al [14] suggested using a variant of the "piggy-back" of Tzakis et al where the common trunk of the receiver is used to receive the cranial extremity of the IVC of the graft. It is this technique (Fig. 1) whose anatomic imperatives we have studied. These techniques as a whole are grouped under the term "piggy-back", a term which illustrates the preservation of the IVC of the receiver. These techniques avoid dissection of the retrohepatic IVC, thus decreasing blood-loss [2, 14, 17, 18]. Only one caval anastomosis is required, which reduces the period of suspension of liver function [2, 14]. Some "piggy-back" techniques allow the preservation of caval flow [2, 5, 14, 17, 18] during performance of the anastomosis, with many advantages: the risks of hemodynamic instability [16, 17], postoperative renal insufficiency and blood-loss [16] are decreased. Resort to a shunt is thus usually avoided [2], with its attendant complications [16]. The absence of clamping of the IVC permits the performance of a temporary portocaval anastomosis [8, 17], which allows complete section of the pedicle, thus facilitating the dissection of the anterior aspect of the retrohepatic IVC [8].

When the common trunk is used, the caval flow can be preserved by performing isolated clamping of this trunk or lateral clamping of the IVC. However, its diameter may not permit an anastomosis without incongruence, whether this relates to the grafting of a hepatic lobe or of a child's liver into an adult [5, 17, 18]. Normally, the diameter of the common trunk is markedly inferior to that of the IVC. Section of this trunk proximal to the junction of the middle and left hepatic vv. thus creates a new ostium whose diameter is close to that of the IVC at its diaphragmatic passage, allowing anastomosis without incongruence. However, this study makes no assumptions about the hemodynamic effects due to the smaller diameter of the actual ostium of the common trunk at its outflow into the IVC. At this site the diameter of the ostium represents only 50% of that of the vena cava. The performance of a "piggy-back" of the middle and left hepatic vv. on the common trunk may, in rare cases, constitute a hemodynamic obstacle to the venous drainage of the graft [12]. Some authors have suggested the construction of a supplementary end-to-side anastomosis between the caudal part of the IVC of the graft and the IVC of the receiver [13]. We cannot compare our measurements, made with a bougie, to those of other authors whose measurements were, at best, given for only two diameters [6, 7, 12, 15].

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