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Review article

Liver hanging maneuver: an anatomic and clinical review

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Abstract

Background: Liver hanging maneuver (LHM) allows to hang the liver during right hepatectomies without primary liver mobilization. The avascular plane used in this technique has been poorly described in the anatomical literature, and intraoperative bleeding because of hepatic vein injuries has been reported.
Data Sources: Major clinical and anatomic articles focusing on the retrohepatic portion of the inferior vena cava (IVC) and the LHM were reviewed.
Conclusions: LHM is as an effective and safe method of guiding hepatic transection to the IVC during right hepatectomies with a feasibility rate up to 95% and minor bleeding in 0% to 6% of cases. According to small series and experts' opinions, LHM would improve parenchymal transection by reducing operative time and blood loss. The tape would ensure a linearly cut surface with IVC safer protection, better exposure, and hemostasis of the deeper plane. Limited remnant liver mobilization could reduce the risk for malignant dissemination and improve liver function. Hepatectomies for huge tumor with diaphragm adhesions could be facilitated. © 2007 Excerpta Medica Inc. All rights reserved.

Keywords: Liver hanging maneuver; Hepatectomy; Liver anatomy; Retro hepatic inferior vena cava

Initially described in 2001 by Belghiti et al [1], the liver hanging maneuver (LHM) is commonly applied to right hepatectomies as an adjunct to the anterior approach described in 1996 by Lai et al [2] and consists in creating, in a blind fashion, a retrohepatic channel between the anterior surface of the inferior vena cava (IVC) and the liver parenchyma, without previous hepatic mobilization. A clamp is passed from down to top in an avascular plane to join the previously dissected space between the right hepatic vein (RHV) on the right and the common trunk of intermediate hepatic vein (IHV) and left hepatic vein (LHV) on the left. Elastic tape is then passed, enabling the surgeon to lift and hang the liver prior to liver transection. This technique facilitates right hepatectomy without liver mobilization and presents potential advantages in terms of shortened operative time; reduced malignant dissemination; improved remnant liver mobilization and function; better surgical exposure, transection, and hemostasis; and safer IVC protection. However, the anatomical basis of this technique is much debated because the avascular plane has been poorly described in the anatomic literature and carries a risk for LHM intraoperative bleeding with hemostatic possibilities, precluded by the absence of previous liver mobilization. Nevertheless, this technique is developing and has been reported to be successfully modified for new indications such as left hepatectomy [3], orthotopic liver transplantation with IVC preservation [4], or living-related liver transplantation [5].

The aim of the present work was to achieve a review of the anatomic basis, feasibility, complication rate, indications, and clinical interest of the LHM based on the relevant literature.

Material and Methods

All studies published since the initial description of LHM in 2001 and focusing on the LHM anatomic basis and operative techniques were retrieved from bibliographic researches on different Internet databases using the following key words: "liver hanging maneuver," "inferior vena cava," and "anatomy." Other anatomic papers focusing on the

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retrohepatic portion of the IVC were found using the same method with the following key words "inferior vena cava," "short hepatic vein," "hepatic vein," and "caudate vein." Additionally, other relevant anatomic books and journals were found in the anatomic library of the Paris Institute of Anatomy. Results in the different series recorded by the major anatomic papers specifically designed to study retrohepatic IVC were also collected and compared.

Results

Technical realization

The dissection starts under visual control with ligation of a caudate hepatic vein and dissection without ligature of an inferior RHV when present. Then the dissection is performed using a clamp in a blind fashion to retrieve the space between RHV and the common trunk previously dissected (Figs. 1 and 2). After dissection is completed, the clamp allows the surgeon to pass the tape used to lift and hang the liver [1].

Anatomic feasibility

Previous reports on LHM anatomic basis [6–10] are confusing because of the absence of a common nomenclature of the hepatic veins, whose classification is not consensual but varying with size, position and drainage territory. For better coherence and clarity, we recommend the following classification derived from the relevant literature and the International Anatomical Terminology [11] (Fig. 3):

1. The main hepatic veins, well described in previous reports, comprise the RHV and the common trunk joining the IHV and the LHV [12].

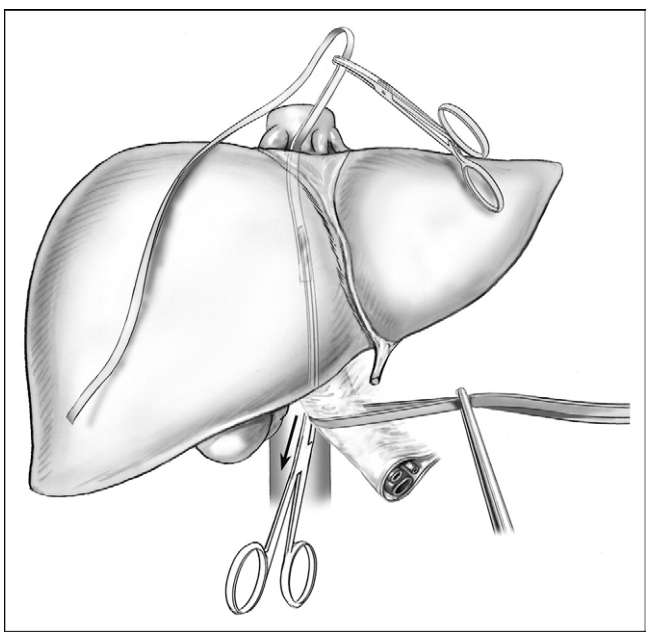


Fig. 1. Blind passage of the clamp on the posterior anterior surface of the retrohepatic IVC. The dissection starts with the dissection between the RHV and the common trunk. The clamp is then introduced from down to top between the anterior face of the retrohepatic IVC and the liver in a blind fashion.

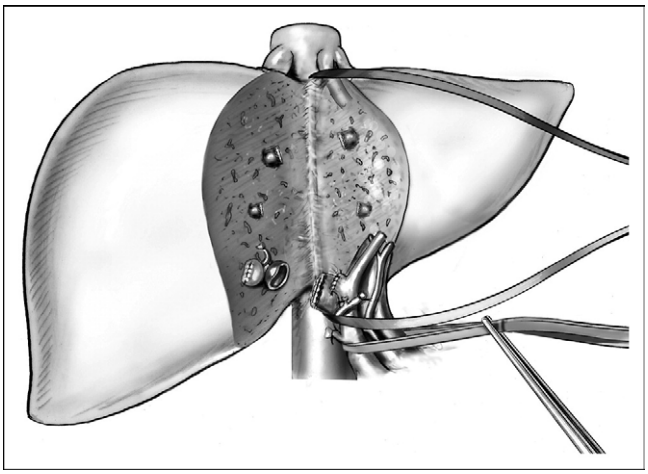


Fig. 2. Anterior view of the LHM lifting the liver with a tape during parenchymal transection.

2. The middle right hepatic vein [6,7,13], when present, most frequently receives the venous drainage of segment 7 and is often unique, with a mean diameter of 2.5 to 7 mm.
3. The inferior right hepatic vein [6,7,9,13] mainly receives the venous drainage of segment 6 and accessory segment 7. It is present in 35% to 100% [7,9] of cases, most frequently unique with a mean diameter of 5 to 7 mm.
4. The short hepatic veins receive the venous drainage of segment 8 on the anterior face of the IVC; they are inconstant and not described by all the authors.
5. The caudate veins (CVs) [6,7,9,13–15] are draining segment 1. Most frequently unique, they have a mean diameter of 3 to 5 mm and are on the anterior left lateral part of the IVC on the lower two thirds, some inframillimetric accessory hepatic veins contributing to the hepatic venous system of the caudate lobe [15].

The LHM prerequisite is the existence of a longitudinal avascular plane between the IVC and the liver, which was first anatomically suggested by Couinaud in 1981 [16–18] and studied later, between 2002 and 2005, in 5 main articles [6–10], including data that are poorly comparable because of discrepancy regarding experimental conditions and anatomic definitions.

The openings of the retrohepatic IVC could make LHM hazardous because of the potential bleeding risks during the clamp passage. For most authors, the length of the retrohepatic portion of the IVC is around 60 mm [1,6–8]. The mean number of the hepatic veins on the retrohepatic IVC is reported to range from 4 to 18 [6,7,9,13,14,19–21] according to the different parameters used, with a mean of 5 to 7 openings of more than 1 mm in diameter on the anterior face (Table 1). The transversal hepatic vein distribution shows that they are mainly present on the lower half [9] or on the middle third (65%) [10,19] of the anterior face of the retrohepatic IVC. Longitudinally, veins are mainly present on the lateral thirds (80 to 90%), with a mean of 0.5 to 2.07 veins per case, depending on various studies [9,10] in the central portion of the IVC, where the clamp is to be inserted.

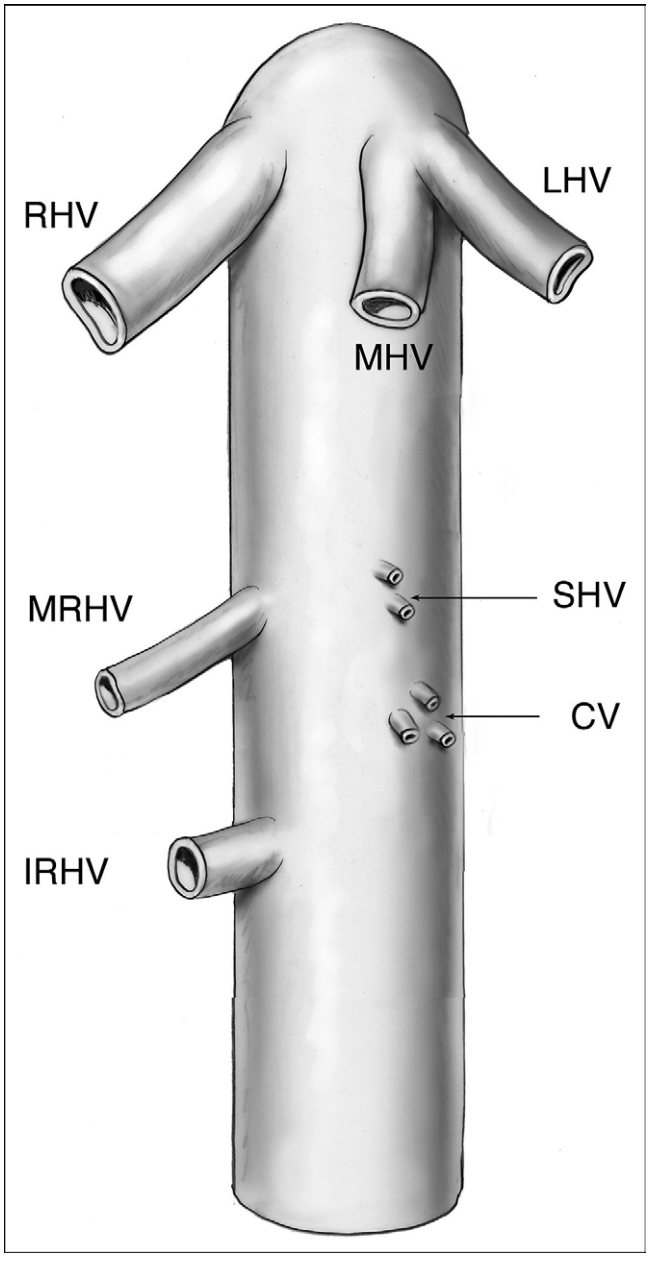


Fig. 3. Diagram showing the openings of the retrohepatic IVC. MRHV, middle right hepatic vein; IRHV, inferior right hepatic vein.

The mean diameter of the openings is small on the anterior face of the IVC [7] (<6 mm in 80%), whereas the veins on the middle transversal third have a diameter <6 mm in 100% of cases [10] and <3 mm in 60%. The hepatic veins of higher diameter (up to 13 mm [7], excluding the main hepatic veins) are always located on the lateral borders of the anterior face of the retrohepatic IVC. Although the anterior face of the IVC is not always avascular, such an avascular plane has been described by some authors [7–9,16–18] and defined as the smallest distance between 2 veins on the clamp progression plane. This distance would be of 8.7 ± 2.3 mm (2–15 mm) for Trotovsek et al [8]. Hirai et al [7] reported a space more than 10 mm wide in 85% of cases. Indeed, the clamp progression seems to be possible in a channel free from any vascular injury risk in 85% to 93% of the cases reported in anatomic studies [6–10] (Fig. 4) and consequently 7% to 15% presence of a passage not truly avascular but only vascularized by a lower density of veins is reported regardless whether the study is cadaveric or in vivo [10].

The direction for the clamp has also been studied in anatomic reports [6–8], and the authors recommended placing the clamp on the right side of the anterior IVC [6,7] and parallel to its axis [8] to minimize the risks for vascular injury.

Clinical feasibility

The clinical feasibility of LHM was shown before the anatomic bases had been first described in a specifically designed study [1]. The bleeding risks were initially reported by Belghiti et al [1] to be 6% (2/32). Since this initial report, the bleeding risks were reported to decrease and now range from 0% to 6% [4,5,10,22,23]. Bleeding during LHM procedure is related to SHV or CV injury but does not entail conversion to a conventional anterior approach in the majority of cases, according to the latest studies [4]. Bleeding is stopped after a light compression on the liver, and often a vein tear has to be sutured after hepatectomy completion. In a recent report, intraoperative blood losses do not seem to be significantly higher than after a conventional procedure [5]. With a view to minimizing SHV and CV injury, localization of the avascular channel has been successfully proposed by using intraoperative ultrasonography [23].

Since the initial study, 5 new studies reported a feasibility rate of 96% to 100% [1,4,5,10,22] (Table 2). The impossibility to pass the clamp was never related to anatomic vascular variations but to the absence of interhepatocaval space because of tumoral infiltration, inflammatory or postoperative close adhesions between the liver and the retrohepatic IVC, and/or an enlarged liver. It has to be specified that the compression of the IVC is not an absolute contraindication in itself to LHM achievement [22], even if it sometimes entails LHM impracticability [24]. So, the only true contraindication to LHM is preoperatively detectable by standard imagery or surgical history. Additionally, LHM can be performed with comparable feasibility rates regardless of whether the liver is normal or cirrhotic [4].

Comments

LHM was initially described and developed for right hepatectomy [1]; it was then further modified for left hep-

Table 1
Mean number of openings of the IVC

	Mean number of openings	Number of subjects
Meng [9]	10.4 (5–15)	13
Sato [6]	3.8	56
Hirai [7]	7.33	173
Chang [20]	8.2	60
Mehran [13]	17 (5–41)	30
Nakamura [21]	18.2	83
Camargo [19]	14.7	30
Ettorre [10]*	5.2	17

All references are cadaveric studies except Ettorre [10].

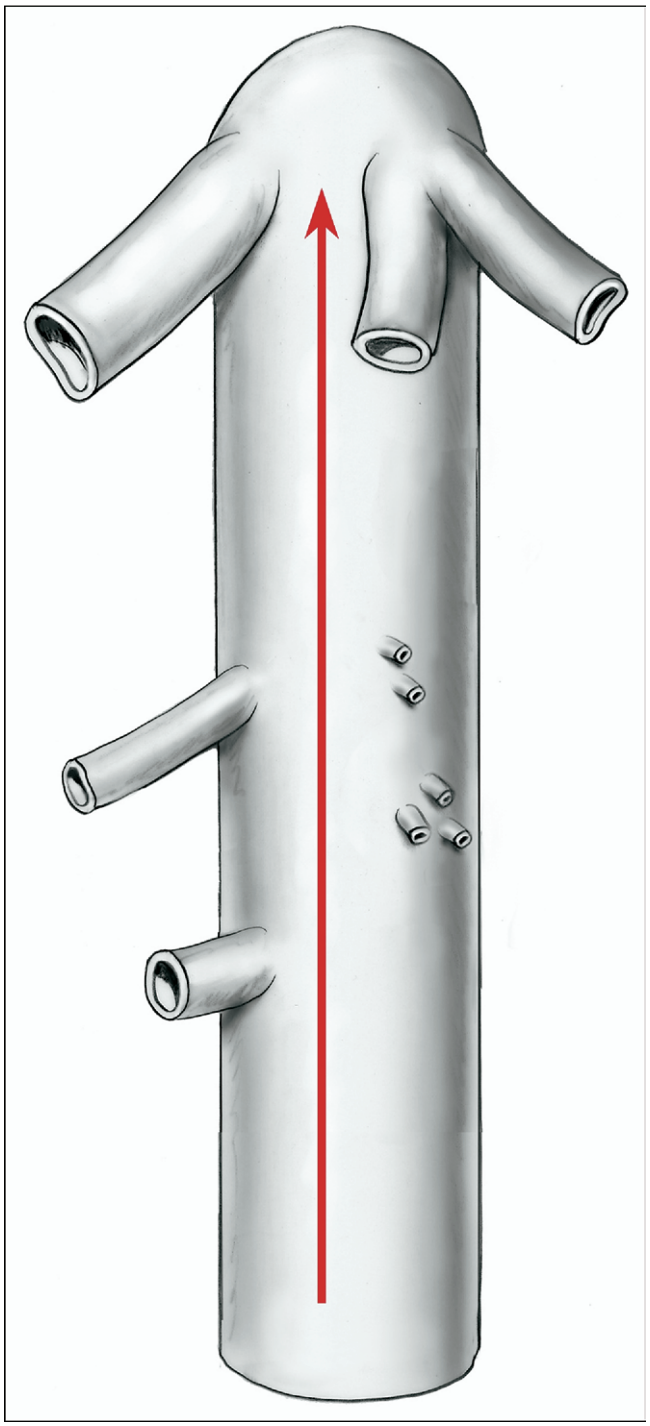


Fig. 4. Direction and position for the clamp during LHM.

atectomy [3], living donor hepatectomy [5,23], and better exposure of the suprahepatic region during hepatectomy in orthotopic liver transplantation with IVC preservation [4]. During living-related liver transplantation, this technique can be used in its initial form [1] to harvest a right liver or, after modifications, to harvest a right liver with or without the middle hepatic vein, a left liver with caudate lobe, or a right lateral sector [5]. For orthotopic liver transplantation, another modification of this technique has been described with a view to better controlling the main hepatic veins in case of IVC preservation [4,25,26]. The feasibility of these modifications of LHM is poorly documented and appears to be of little concern [3]. In addition, some of these modifications do not use the plane of the IHV that defines the original LHM.

Notwithstanding, various reports confirmed the high feasibility [1,4,5,22,23] and low bleeding rate of LHM in right hepatectomies for neoplastic or benign tumors, but the anatomic basis remained unclear. The existence of an avascular plane between the IVC and the liver parenchyma was first suggested by Couinaud [16] in 1981 and then reported in 2001 in Belghiti's technical article [1]. Since 2001, several anatomic studies proved the existence in a great majority of cases of an avascular channel in the middle part of the anterior retrohepatic IVC. In a minority of cases, the presence of small-diameter hepatic veins has been reported in the avascular channel, and, among them, CV are considered by some authors as the most dangerous during retrohepatic dissection [23].

However, the anatomic studies focusing on the avascular plane, except that they all recommend to place the clamp on the right of the IVC parallel to its axis [6,9], are of poor clinical interest [6,8,9] because their results are biased by the use of too different material (fresh cadaveric livers, formalin-fixed livers, in situ livers or on table, and cadaveric or living subjects) and methods (various ways to divide the entire IVC or part of it, by a clamp, a strip of paper, or a wire).

To the best of our knowledge, no embryologic explanation for the existence of such a poorly documented avascular plane, either in humans or animals, has been reported, even if the hepatic origin of the retro hepatic IVC has been assessed. (JM Chevallier, unpublished data, 1989). Nevertheless, the anatomic basis of the LHM is confirmed by its high feasibility and throws a new light on the anatomic identity of the retrohepatic portion of the IVC.

Bleeding, when it occurs, is most frequently minor, and cases necessitating conversion to an anterior approach are few [1] and are decreasing with the growing surgical team experience. Nevertheless, the bleeding risk is the major challenge of this technique because it is not easily controlled, despite new refinements such as successful recourse to intraoperative ultrasound [23]. The presence of SHV and CV in the channel has been shown by anatomic studies pointing to a 7% to 15% risk for vein injury, whereas the bleeding rate clinically observed is very low, not exceeding 6%. Such discrepancy between the bleeding rate clinically observed and the higher bleeding risk anatomically observed may result from 2 specific conditions. First, the SHV and CV in the channel are of small diameter. Second, the high density of smooth muscle tissue in the adventitia of the retrohepatic IVC shown by Kanamura et al [14] has been hypothesized by Sato et al [6] as a stimulation for rapid hemostasis in case of small hepatic vein damage. In addition, the low central venous blood pressure controlled by the anesthetist team during hepatectomy, as recommended, helps to reduce the blood loss in case of hepatic vein injury.

LHM has been reported to have numerous advantages especially in terms of shortened operative time and reduced blood loss, but these are not shown by clinical comparative

Table 2
Technical feasibilty and indications for LHM in the literature

	Indications	Planned	Done	Intraoperative bleeding	Bleeding-related interrruption
Belghiti [1]	32 RH (Including 12 LD)	32	32	2 (6%)	2 (Switch to conventional anterior approach)
Kokudo [5]	37 RH 8 RHM 20 LH (Including segment I) 6 RLS	71	71	1 (1.40%)	1 (Switch to conventional anterior approach)
Susuki [22]	5 RH (With IVC compression)	5	5	0%	0
Ettorre [4]	26 RH	26	24	1 (4%)	0
Ettorre [10]	45 RH 34 LH (Including segment I) 1 CH	49	47	1 (2%)	0

RH = right hepatectomy without intermediate hepatic vein; RHM = right hepatectomy with intermediate hepatic vein; LH = left hepatectomy; RLS = right lateral sectoriectomy; CH = central hepatectomy (segment IV V VIII); LD = living donor.

studies and are mainly based on experts' opinions. Moreover, the LHM avoids liver rotation with lower risk for tumor dissemination and higher possibilities of oncologic benefits, helps to reduce remnant liver manipulation with potential improvement in postoperative liver function, and allows better exposure and hemostasis of the deeper section plane with safer IVC protection. Additionally, the tension on the elastic tape would help to obtain a linearly cut surface and would avoid the zigzag manner, thereby contributing to protection of the IVC from surgical injury. Furthermore, the hepatectomies in cases of huge tumors with diaphragm adhesions would be facilitated.

LHM seems to be a real improvement in the method used for guiding transection to the IVC during right hepatectomy. Based on the existence of an avascular plane observed in 85% to 93% of cases, LHM allows the surgeon to successfully pass a clamp in more than 95% of cases with a minor bleeding risk of about 5%. This bleeding risk is decreasing with experience, but some IVC injuries could have to be controlled during learning curve, which should be of great concern for surgeons, especially when they are practicing outside expert centers. LHM benefits have therefore to be assessed and compared with LHM hazards.

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