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NEW METHOD OF SURGICAL CONTROL OF RETROHEPATIC IVC: ANATOMICAL STUDY

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Abstract. *The study presents results of our anatomical investigation of feasibility of a new surgical maneuver: formation of a cross-tunnel under the mouths of the major hepatic veins during removal of a tumor thrombus of the inferior vena cava. The parameters of this surgical approach were compared with the results of "piggyback" liver mobilization. Our results have demonstrated possibility of forming a tunnel under the mouths of the major hepatic veins in 80% of cases. This maneuver has similar risk level parameters compared to "piggyback" mobilization of the liver. No prognostic factors for feasibility of such an approach were identified. Further clinical study is definitely required to determine its effectiveness.*

Key words: *inferior vena cava, tumor thrombus, piggyback mobilization of the liver, cross-tunnel*

Introduction

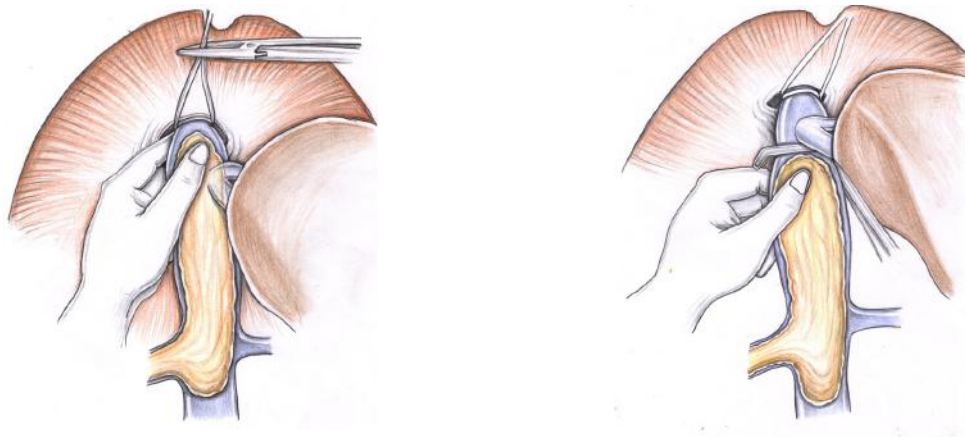
Obvious limitations of high tumor thrombus removal with the use of balloon catheters or cardiopulmonary bypass have determined the development of alternative methods making it possible to fully control subhepatic, retrohepatic and intrapericardial segments of the inferior vena cava (IVC) [1, 2]. The most important aspect of this approach is the feasibility of external digital displacement of the thrombus apex below the diaphragm [3, 4]. However, due to weakness of caval collateral vessel development the clamping of the IVC above the insertions of the major hepatic veins can lead to serious hemodynamic changes. Therefore, the main task of a surgeon in such a situation is to further displace the thrombus downwards and clamp the IVC below the mouths of the major hepatic veins [5,6] (Figure 1a, b). This maneuver allows us to maintain the hepatic blood flow, which accounts for about 25% of blood inflow to the inferior vena cava. The essential condition for performing this stage of the operation is to carry out the liver mobilization using the classical and "piggyback" methods [2].

During the classical variant the liver is mobilized *en bloc* together with the inferior vena cava. It requires ligation and transection of the right lumbar, adrenal and inferior phrenic veins and complete separation of retrohepatic IVC from the posterior abdominal wall.

The "piggyback" technique is characterized by maximum separation of the anterior surface of the inferior vena cava from the liver (only major hepatic veins are preserved) via transection of the small hepatic veins draining the caudate lobe. The terminal regions and mouths of the major hepatic veins are carefully mobilized.

To facilitate the mobilization of the retrohepatic IVC Belghiti J. et al. proposed a liver-hanging maneuver [7]. It included passing the tape through between the front surface of the inferior vena cava and the rear surface of the hepatic parenchyma [8].

Elevation of the liver with the help of a tape provides a better overview of the entire suprahepatic space and significantly facilitates manipulations on the hepatic veins and intrapericardial section of the IVC, especially in cases of severe hepatomegaly.



A b

Figure 1 **a** Digital fixation of tumor thrombus; **b** Displacement of the thrombus apex below the mouths of the major hepatic veins.

However, one should bear in mind that due to the problems associated with venous anatomy, "piggyback" mobilization of the liver is possible to perform only in 80-92% of cases [2]. In a number of observations the major hepatic veins and veins of the caudate lobe of the liver have got a very short extrahepatic portion, quite thin walls and a variable location. Besides, in some patients several dozens of veins draining into the retrohepatic IVC are found.

All the above mentioned factors predispose to trauma of the veins, which in its turn can cause heavy bleeding. Iatrogenic injury of the short hepatic veins is the most unfavorable complication of this procedure. It is observed in approximately 4-6% of patients [8].

From our point of view, "piggyback" mobilization of the liver is not always required. This primarily relates to the situations where the liver covers less than half the circumference of the retrohepatic vena cava segment. At the same time, in order to bring the thrombus down it is enough to mobilize the liver using the classical variant, and to release the posterior vena cava.

Taking into account the geometrical features of the retrohepatic IVC and major hepatic veins, as well as the imaging findings, we have assumed that there is an vascular zone immediately below the mouths of the major hepatic veins, which is about 1.0 cm wide, through which a vascular clamp can be passed without performing the "piggyback" mobilization of the liver (Figure 2).

Thus, a surgeon with his hand above the thrombus apex and grasping the vena cava posteriorly and laterally, rather than circularly, can easily displace the thrombus below the mouths of the major hepatic veins. At the same time, the clamp above the apex of the thrombus can be passed through the cross-tunnel directly under the mouths of the major hepatic veins (Figure 3).

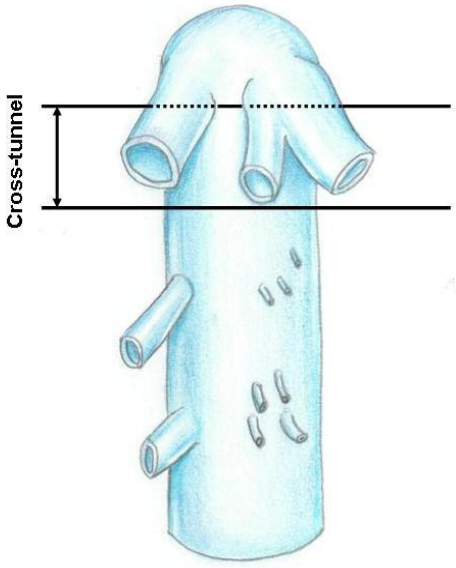


Figure 2. Layout of cross-tunnel below a mouth of the major hepatic veins

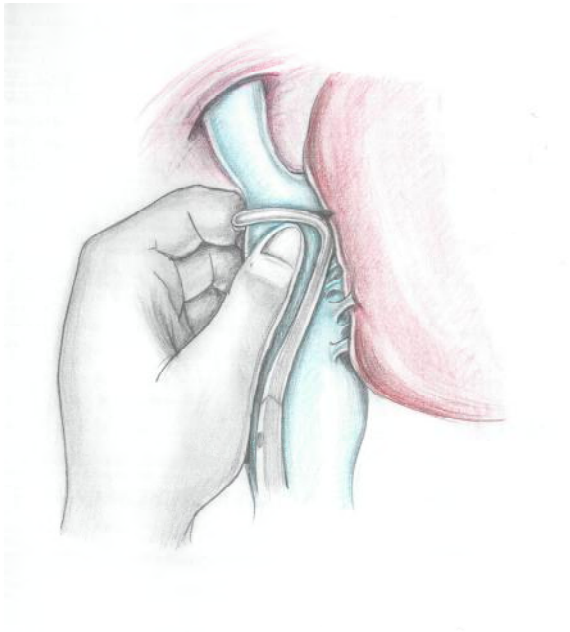


Figure 3. The clamp above the apex of the thrombus passed through the cross-tunnel directly under the mouths of the major hepatic veins.

To confirm this hypothesis we performed an anatomical study of the retrohepatic IVC regarding the assessment of feasibility and risk level of two options of surgical approaches to this segment of the IVC: "piggyback" mobilization of the liver and creation of a cross-tunnel under the mouths of the major hepatic veins.

Materials and methods

The materials for this anatomical study were 35 fresh cadavers (less than 48 hours after death). The autopsies were performed between June and September 2012 on the base of the departments of Pathological Anatomy of Hospital No.8 and Regional Clinical Center of Urology and Nephrology in the city of Kharkov, Ukraine. The age of the deceased patients (18 men and 17 women) ranged from 42 to 85 years and was 69.3 years in average. The mean height did not exceed 168 cm, and the weight was not more than 82 kg.

In order to examine the characteristics of the intrapericardial IVC and its tributaries we used the following method. After removal of the organs using *en masse* technique, the posterior surface of the entire length of inferior vena cava was sharply and bluntly exposed. Then, the organs were turned their ventral side up and the mobilization of the liver was performed using the classical method (transection of the falciform, triangular and coronary ligaments), which allowed us to expose the suprahepatic infradiaphragmatic IVC with the mouths of the major hepatic veins. Afterwards, we tried to bluntly create a cross-tunnel about 1.0 cm wide immediately below the mouths of the main hepatic veins without "piggyback" mobilization of the liver with evaluation of probability of hepatic and vascular injury.

Thereafter, the vena cava was opened longitudinally from the bifurcation up to the retrohepatic segment of the IVC. The incision was made along the left lateral

surface of the vein at 9 o'clock to preserve the posterior wall of the IVC as much as possible. At the level of retrohepatic segment the inferior vena cava was dissected longitudinally along the midline. When the incision was completed the rear IVC wall was turned away outwards, making it possible to examine the mouths of the main inflows of the IVC on its front and rear surface. We examined the length and diameter of each segment of the inferior vena cava, as well as the size of each venous tributary mouth. For topographic recording of the mouths of the hepatic veins the retrohepatic segment of IVC was conventionally divided into 12 sections, which were entered into a special chart. The major hepatic veins were described as the upper right, middle and left. Others, smaller venous vessels draining into the posterior surface of the liver (dorsal hepatic veins) were classified according to De Cecchis et al. [9]. When the diameter of the mouth was more than 4 mm the lower right and middle right hepatic veins were exposed [10]. The veins of the caudate lobe of the liver and other small venous tributaries were examined separately. Taking into account the location, size and number of the venous mouths the feasibility and risk level of "piggyback" mobilization of the liver were studied. We took photographs of all the stages of our anatomical study.

Feasibility of "piggyback" mobilization of the liver and formation of a tunnel under the mouths of the major hepatic veins was assessed using the following scale: easy (100 points), difficult (50 points), impossible (0 points). The risk level of the operation was graded as safe (100 points), risky (50 points), and which caused the trauma of the vessels or liver parenchyma (0 points).

Results and discussion

The main results of the study are presented in Tables 1-4. The average length of retrohepatic IVC was 85.8 mm (70 mm to 130 mm), and the diameter was 31.1 mm (25 mm to 40 mm). The retrohepatic IVC was completely surrounded by the liver in 1 case (2.9%), half the circumference in 17 cases (48.5%), 2/3 in 16 (45.7%), and 1/3 only in one case (2.9%).

Table 1.

Feasibility values for "piggyback" mobilization of the liver and formation of a tunnel under the mouths of the major hepatic veins.

Feasibility	Easy		Difficult		Impossible		Average score
	N	%	n	%	n	%	points
"Piggyback" mobilization	7	20	24	68.6	4	11.4	54.3
Formation of a tunnel under the major hepatic veins	11	31.4	17	48.6	7	20	55.7

Table 2.

Risk level values for "piggyback" mobilization of the liver and formation of a tunnel under the insertions of the major hepatic veins.

Safety	Safe		Risky		Trauma		Average score
	N	%	n	%	n	%	points
"Piggyback"mobilization	1	2.9	29	82.8	5	14.3	44.3
Formation of a tunnel under the major hepatic veins	0	0	25	71.4	10	28.6	35.7

The number of mouths of all types of the hepatic veins varied from 4 to 16, and averaged7.6. The mean number of dorsal vein mouths of the liver 3 mm in diameter did not exceed 5.1 (1 to 14) and >3 mm was 2.5 (0 to 5).

"Piggyback" mobilization of the liver was graded as "impossible" in 4 cases (11.4%), its feasibility was "difficult" in 24 cases (68.6%). In respect of the tunnel under the mouths of the major hepatic veins it should be noted that its formation was not possible in 7 cases (20%). Nevertheless, in 11 cases (31.4%) formation of the tunnel was graded as "easy" (Figure 4).

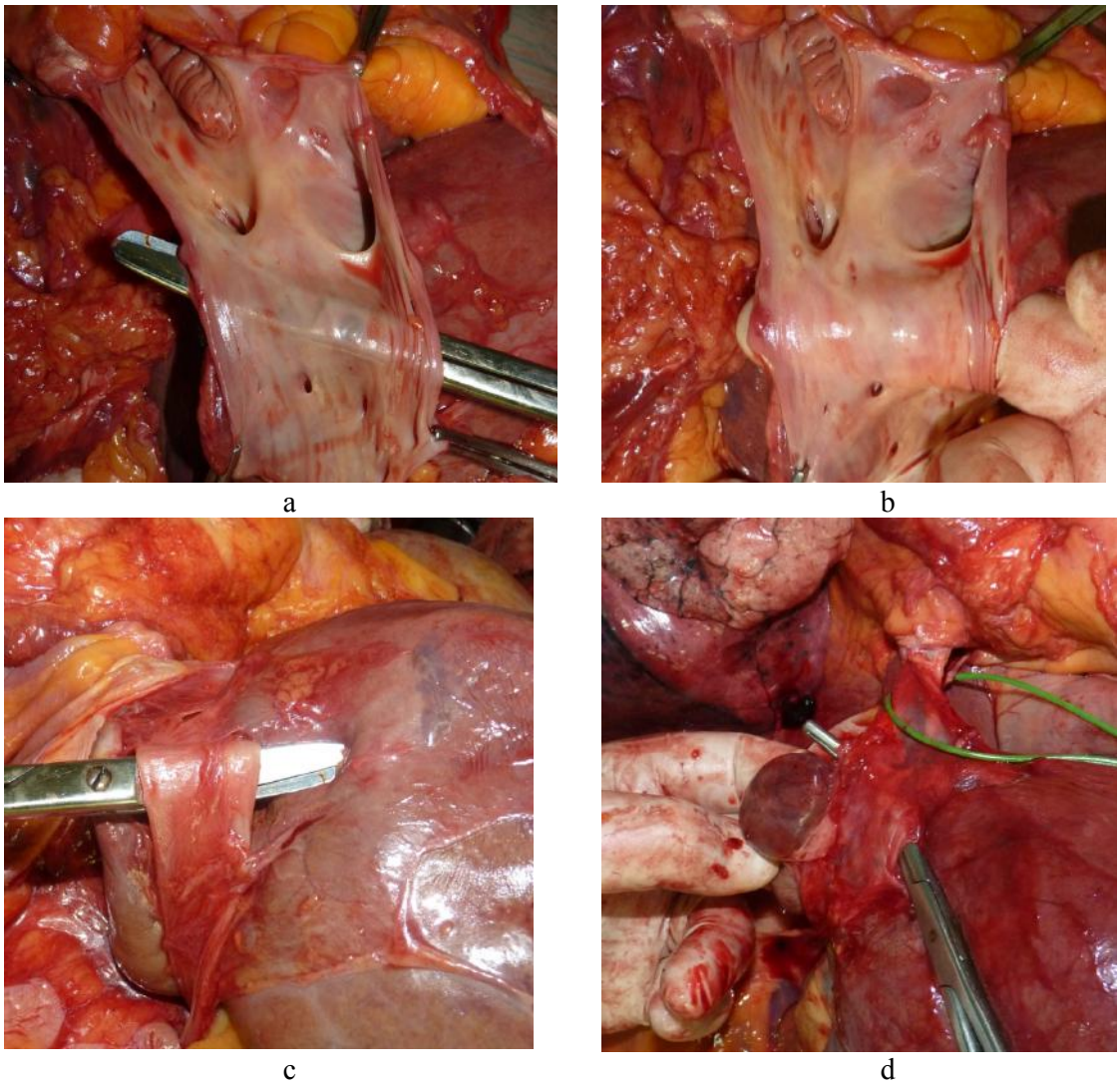


Figure 4 a, b, c, d Autopsy observations of successful and safe formation of the cross-tunnel below the mouths of major hepatic veins.

Injury of the liver parenchyma, hepatic veins or inferior vena cava was established in 14.3% of the cases using "piggyback" mobilization of the liver, where as formation of a tunnel under the mouths of the hepatic veins caused the similar problems in 28.6% of cases (Figure 5).

Nevertheless, the risk level values were slightly higher for "piggyback" mobilization of the liver (82.8% vs. 71.4%). Combination of parameters "easy +

risky" was more frequently observed during formation of the tunnel (31.5% vs. 17.1%), while parameters "difficult + risky" occurred more frequently during "piggyback" mobilization of the liver (62.9% vs. 40.0%). It is of interest, that impossibility of "piggyback" mobilization and formation of the tunnel was noted only in one patient. Feasibility of "piggyback" mobilization did not correlate with the ability to create a tunnel.

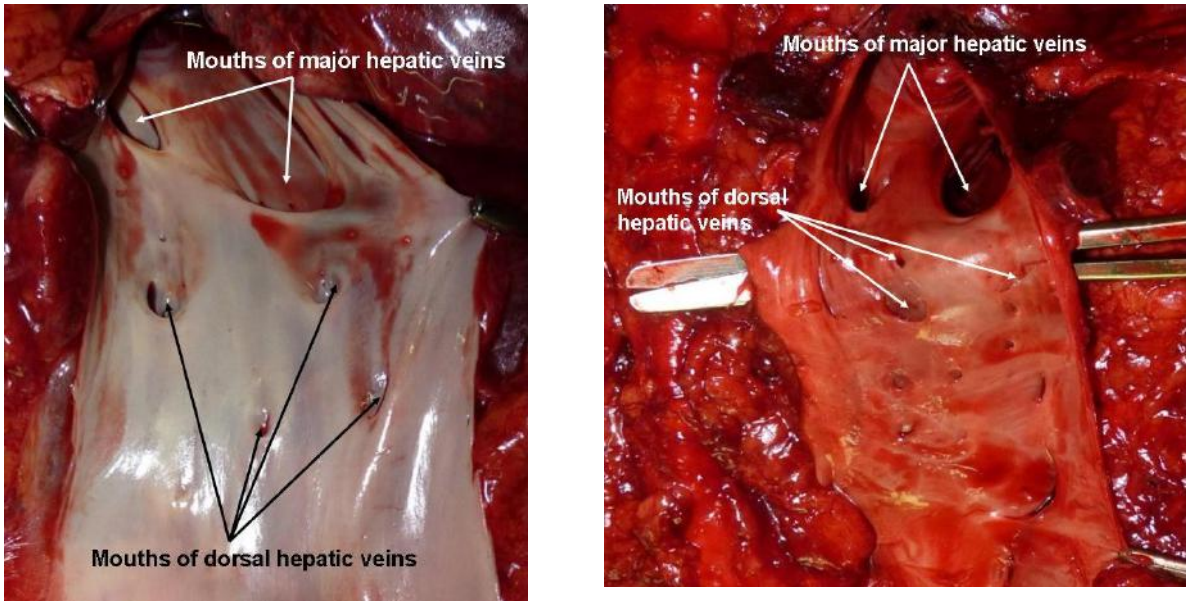


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Figure 5. Autopsy observations of difficult and risky formation of the cross-tunnel.

Among feasibility prognostic parameters of "piggyback" mobilization of the liver only the quantity of mouths of the hepatic veins ($p < 0.05$) was statistically significant. None of the three examined parameters have demonstrated their validity in terms of predicting the feasibility of tunnel creation under the mouths of the major hepatic veins.

Table 3.

The values of parameter combination of feasibility and safety for "piggyback" mobilization of the liver and formation of a tunnel under the mouths of the major hepatic veins.

Combination of parameters	"Piggyback"mobilization		Formation of a tunnel under the major hepatic veins	
	n	%	n	%
Easy + safe	1	2.9	0	0
Easy + risky	6	17.1	11	31.5
Easy + trauma	0	0	0	0
Difficult + safe	0	0	0	0
Difficult + risky	22	62.9	14	40
Difficult + trauma	2	5.7	3	8.5
Impossible + risky	1	2.9	0	0
Impossible + trauma	3	8.5	7	20
Total	35	100	35	100

Table 4.

The prognostic value of some parameters as for feasibility of "piggyback" mobilization of the liver and formation of a tunnel under the mouths of the major hepatic veins.

Prognostic parameter	"Piggyback" mobilization (p)	Formation of a tunnel under the major hepatic veins (p)
Length of retrohepatic IVC	0.067	0.086
Length of circumference of IVC covered with the liver	0.056	0.696
The number of hepatic vein mouths	0.024	0.425

The results of our study have demonstrated that "piggyback" mobilization of the liver is possible in about 90% of cases, whereas formation of a tunnel under the mouths of the major hepatic veins is possible in 80% of cases. It is interesting, that both variants of access to the retrohepatic segment of the IVC were not possible only in 1 case (2.9%). Therefore, we believe that difficulties either approach can be compensated for by using the other one.

Both approaches have demonstrated rather high risk levels (82.8%, and 71.4%).However, the combination of parameters "easy + risky" in a more proportion of cases was observed during creation of a tunnel, while parameters "difficult + risky" much more frequently occurred during "piggyback" mobilization of the liver. Of course, one of the drawbacks of our study was a certain subjectivity of the results despite our efforts to unify this value by the way of creating a scale of feasibility and risk level of the operation stages. There is no doubt that the most considerable factor influencing the evaluation of these parameters is the experience of hepatic surgery and the knowledge of anatomy possessed by a surgeon performing removal of the tumor thrombus.

Another important aspect of the study was to identify possible prognostic performance factors of "piggyback" mobilization of the liver and formation of a tunnel under the mouths of the major hepatic veins. For performing "piggyback" mobilization of the liver the only one statistically significant prognostic parameter was identified, which was the number of mouths of the hepatic veins. None of the examined parameters demonstrated any statistical significance for predicting tunnel formation.

Our work presents a model access to the retrohepatic inferior vena cava via creation of a tunnel under the mouths of the major hepatic veins during an anatomic study. More detailed and objective evaluation of this approach requires further clinical investigation. There is no doubt that intraoperative ultrasonography of the liver can greatly facilitate the performance and reduce the risk level during creating a tunnel under the mouths of the major hepatic veins.

Conclusions

The results of our anatomical study have demonstrated feasibility of performing new maneuver during vena cava thrombectomy by the way of forming a cross-tunnel under the mouths of the major hepatic veins in 80% of cases. This

approach has similar risk level parameters compared to “piggyback” mobilization of the liver. Noprognostic factors for feasibility of this maneuver were identified. In order to determine the effectiveness of this approach further clinical study is required.

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Лісовий В.М., Щукін Д.В., Гарагатий І.А., Поляков М.М., Хареба Г.Г.

Новий метод хірургічного контролю ретропечінкового сегменту НПВ: анатомічне дослідження

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Резюме. У нашій роботі представлені результати анатомічного дослідження можливості виконання нового хірургічного маневру - формування поперечного тунелю під вічками головних печінкових вен при видаленні пухлинних тромбів нижньої порожнистої вени. Параметри даного хірургічного підходу порівнювалися з результатами piggyback мобілізації печінки. Результати нашої роботи продемонстрували можливість формування тунелю під вічками

головних печінкових вен у 80% пацієнтів. Даний маневр має подібні показники рівня ризику в порівнянні з piggyback мобілізацією печінки. Яких-небудь прогностичних факторів щодо можливості виконання такого підходу ідентифіковано не було. Для визначення його ефективності необхідно подальше клінічне дослідження.
Ключові слова: нижня порожниста вена, пухлинний тромб, piggyback мобілізація печінки, поперечний тунель

Лесовой В.Н., Щукин Д.В., Гарагатый И.А., Поляков Н.Н., Хареба Г.Г.

Новый метод хирургического контроля ретропеченочного сегмента НПВ: анатомическое исследование

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Резюме. В нашей работе представлены результаты анатомического исследования возможности выполнения нового хирургического маневра - формирования поперечного тоннеля под устьями главных печеночных вен при удалении опухолевых тромбов нижней полой вены. Параметры данного хирургического подхода сравнивались с результатами piggyback мобилизации печени. Результаты нашей работы продемонстрировали возможность формирования тоннеля под устьями главных печеночных вен у 80% пациентов. Данный маневр имеет сходные показатели уровня риска в сравнении с piggyback мобилизацией печени. Каких-либо прогностических факторов в отношении выполнимости такого подхода идентифицировано не было. Для определения его эффективности необходимо дальнейшее клиническое исследование.
Ключевые слова: нижняя полая вена, опухолевый тромб, piggyback мобилизация печени, поперечный тоннель

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