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Cross-clamping of the three hepatic veins in the piggyback technique is a safe and well tolerated procedure

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Abstract A common stump of the three hepatic veins has always been used to fashion the upper vena cava anastomosis in 205 liver transplantations with the piggyback (PGB) technique performed in our Unit, to avoid outflow problems. The aim was to study the repercussion of lateral inferior vena cava (IVC) clamping on IVC flow and pressure as well as on systemic hemodynamics. We have studied 42 orthotopic liver transplantations performed with the PGB technique. Intraoperative IVC blood flow measurements by transit time ultrasonic volume flowmetry, IVC pressure, and systemic hemodynamics were taken before and after lateral IVC clamping. Graft outflow complications, stenosis or kinking of the upper vena cava anastomosis have not been found in any of the 205 PGB procedures. A significant decrease of IVC flow (23 %) and cardiac output (12 %) occurred after IVC clamping,whereas mean arterial and central venous pressures were not altered significantly, probably due to an increase (25 %) of systemic vascular resistance. Only in one case was an almost total clamping of IVC needed. Venovenous bypass was not needed in any case. Renal perfusion pressure was adequate in all cases. We conclude that the use of a common stump of the three hepatic veins for upper vena cava anastomosis in the PGB technique is safe because any outflow problem of the graft is avoided and, at the same time, is well tolerated hemodynamically because most of the IVC flow is preserved.

Key words Liver transplantation · Piggyback technique · Systemic hemodynamics · Inferior vena cava flow measurements

Introduction

Recipient hepatectomy with preservation of the inferior vena cava (IVC) or the piggyback technique (PGB) is an excellent alternative to venovenous bypass to achieve hemodynamic stability during the anhepatic phase in adult patients undergoing liver transplantation (LT). We adopted the PGB technique in 1991 as routine procedure in our program of adult LT. Since then, it has been performed in 93 % of cases [1]. A common stump of the three hepatic veins has always been used to fashion the upper vena cava anastomosis to obtain a wide anastomosis and to avoid the outflow problems which have been described when only two hepatic veins are used.The aim was to study the repercussion of lateral IVC clamping on IVC blood flow and pressure as well as on systemic hemodynamics.

Materials and methods

Since 1991, 220 LT have been performed in our Unit. The PGB technique was used in 205 cases (93.2 %). From 1996, a hemodynamic study was undertaken in 42 LT performed in 39 patients. Characteristics of these 42 cases are presented in Table 1.

Table 1 Patient characteristics (Child-Pugh: A = 9, B = 15, C = 13)

Number of patients	39
Male	24
Female	15
Number of liver transplants	42
Mean age (years)	58.2 ± 8
Indications	
Cirrhosis	37
Hepatocellular carcinoma	16
Hepatitis C virus	9
Hepatitis B virus	2
Alcohol	6
Primary biliary cirrhosis	2
Autoimmune	1
Idiopathic	1
Primary sclerosing cholangitis	1
Retransplant	
Urgent, primary non-function	3
Elective, arterial thrombosis	1

Surgical technique

Hepatic hilum was dissected first and the common bile duct and hepatic artery were ligated and divided. Hepatic ligaments were taken down and the liver was dissected out from the IVC by ligating and dividing all venous branches until the three hepatic veins were completely dissected. Vascular clamps were placed first on the portal vein and then on the IVC near the entrance of the three hepatic veins. Finally, these veins were divided close to the liver. A common stump of the three hepatic veins was fashioned by joining the three venous orifices. Graft implantation was performed by anastomosing the upper donor IVC to a common stump of the three hepatic veins, then portal and arterial anastomoses were done. The liver was flushed with blood by releasing the portal clamp. The infrahepatic donor IVC was clamped and sutured and the upper caval clamp was released. The liver was completely revascularized and finally the biliary anastomosis was performed.

Intraoperative blood flow measurements

A 21- or 12-mm ultrasound transit time probe was placed around the IVC below the hepatic veins and blood flow measurements were taken through a Cardiomed flowmeter (CM 4008; Medi-Stim, Oslo, Norway) before and after a vascular clamp was placed on the IVC. At the same time, IVC pressure (IVCP) was obtained through a catheter introduced into the retrohepatic IVC and general hemodynamic data were taken through a Swan-Ganz catheter. Cardiac output and cardiac index were measured by thermodilution. Results are presented as mean and standard deviation. Differences in IVC blood flow and venous pressures and general hemodynamics before and after IVC clamping were analyzed with Student's paired *t*-test.

Results

Graft outflow complications, stenosis or kinking of the upper vena cava anastomosis have not been found in any of the 205 PGB procedures performed in our program.

Results of intraoperative blood flow measurements and general hemodynamics performed in these 42 cases are presented in Table 2. A significant decrease of IVC blood flow and cardiac output occurred after IVC clamping, whereas mean arterial and central venous pressures did not change significantly. Therefore, a 23% decrease of IVC flow was compensated by a 25% increase of systemic vascular resistance, resulting in a slight and well tolerated decrease of cardiac output of only 12%.

Only in one case was an almost total clamping of the IVC needed (IVC flow = 44 ml/min, IVCP = 30 mmHg). The IVC flow decreased by more than 50% in only four cases (9.5%) and was less than 1000 ml/min in six cases (14%). Cardiac output decreased more than 30% in six cases (14%). Renal perfusion pressure was adequate in all cases. Veno–venous bypass was not needed in any case.

Discussion

Hepatectomy with IVC preservation or PGB is our technique of choice in orthotopic LT. It can be performed in the majority of cases, thereby avoiding the use of venovenous bypass [2]. Consequently, operating time, blood transfusions, complications, and cost are reduced [1]. Different variants of the PGB technique have been described by increasing the number of supporters [3–7]. Generally, the right hepatic vein is sutured and a common stump of middle and left hepatic veins is used for anastomosis. This is technically easier and minimal

Table 2 Hemodynamic study of 42 liver transplantations (*IVC* inferior vena cava, *SVR* systemic vascular resistance, *SVRI* systemic vascular resistance index, *MAP* mean arterial pressure, *CVP* inferior vena cava pressure, *NS* not significant)

	Pre-IVC clamping	Post-IVC clamping	Differences	(%)	*P*
IVC flow (ml/min)	2502 ± 1103	1963 ± 1174	539 ± 536	(23)	< 0.001
IVC pressure (mmHg)	10.4 ± 4.1	13.8 ± 5.9	3.4 ± 5.8	(46)	0.002
Cardiac output (l/min)	6.1 ± 2.4	5.3 ± 2.5	0.8 ± 0.9	(12.8)	< 0.001
Cardiac index (l/min/m^2)	3.6 ± 1.3	3.1 ± 1.4	0.4 ± 0.6	(11.7)	< 0.001
SVR (dyn · s · cm^{-5})	792 ± 361	978 ± 441	187 ± 274	(25.4)	0.002
SVRI (dyn · s · cm^{-5}/m^2)	1363 ± 532	1678 ± 701	314 ± 479	(24.5)	0.003
MAP (mmHg)	68.5 ± 11.3	65.5 ± 16.2	3 ± 12	(4.3)	NS
CVP (mmHg)	10.3 ± 4.1	9.8 ± 3.9	0.5 ± 2.6	(2)	NS

clamping of the IVC is needed. However, graft outflow can be compromised due to a narrow orifice or kinking of the anastomosis when the liver is positioned in the hepatic fossa. When this anastomotic orifice is widened by incision of the IVC to the right, almost total clamping of the IVC is needed to perform the anastomosis. Lerut et al. [7] reported a 43% need of venovenous bypass in the PGB technique when total IVC clamping was performed. They advocate a laterolateral cavocaval anastomosis with partial clamping of IVC as a better alternative to the PGB technique with no need for venovenous bypass in their experience [7, 8].

A temporary portacaval shunt is added to the PGB technique by some authors [9, 10] to decompress the splachnic territory during the anhepatic phase, particularly in patients without portosystemic collaterals, as in fulminant or subfulminant hepatitis.

We advocate the routine use of a wide stump of the three hepatic veins to avoid any outflow problems, stenosis or kinking of the anastomosis. A portacaval shunt is not necessary if portal vein occlusion is performed just before hepatectomy is completed.Therefore, only 15 min more of portal clamping, the time for performing the upper vena cava anastomosis, is added to the time for doing the portal anastomosis. Even patients without previous portal hypertension and portosystemic collaterals can stand such a short period of venous occlusion of splachnic territory. Partial clamping of the IVC is necessary to include the three hepatic veins in order to fashion a common stump for anastomosis. In this study we demonstrate that most of the caval blood flow is maintained, therefore there is little repercussion on general hemodynamics. Total clamping of the portal vein and IVC produces a decrease of 40–50% of cardiac index and an increase of 75–90% of the systemic vascular resistance index, whereas partial IVC clamping to include the three hepatic veins produced minimal reduction in cardiac output and increase in systemic vascular resistance, similar to that in patients with venovenous bypass [11–15]. Furthermore, reversal of the hyperdynamic state after hepatectomy could be responsible, to some extent, for reductions in cardiac output and IVC flow secondary to an increase in systemic vascular resistance [9]. Intraoperative IVC flow measurements allowed us to place the IVC clamp in the best position for performing the vascular anastomosis while IVC flow is less disturbed.

In conclusion, the use of a common stump of three hepatic veins for upper vena cava anastomosis in the PGB technique is safe because any outflow problem of the graft is avoided and, at the same time, is well tolerated hemodynamically because most of the IVC flow is preserved.

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