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Clinical application of arterialization of portal vein in living related donor partial liver transplantation

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Abstract. Arterialization of the portal vein was employed during hepatic arterial reconstruction in our first few clinical experiences of partial liver transplantation using liver grafts obtained from living related donors. This procedure reduced the time required for revascularization of the grafts to about 25 min, and could in fact reduce the ischemic phase of the grafts. Repeated practice of the clinical transplantation technique has shortened the time needed to complete vascular reconstruction, eliminating the need for this procedure in most of our subsequent cases. In many clinical cases, however, there may be emergency situations which require vascular reconstruction, resulting in a prolongation of ischemic phase and the deterioration of the cellular viability of the graft. In such situations, arterialization of the portal vein can be a useful way to prevent the prolongation of the ischemic phase and to rescue the graft.

Key words: Liver transplantation, living related donor – Portal vein reconstruction in liver transplantation, living related donor – Living related donor, liver – Vascular reconstruction, living related liver donation

Partial liver transplantation using liver grafts obtained from related living donors, which has been recently proposed for pediatric cases, can provide genetically and immunologically more compatible grafts than those from brain-dead patients, and can also minimize the cold ischemic injury by controlling both the donor and recipient operations [2, 7]. However, the delay between the put-in and reperfusion of the graft should be kept as short as possible, even when the cold ischemic time is minimal.

Since June 1990 we have performed clinical partial liver transplantation in 14 cases using living related donors. In our first few experiences, we effectively reduced the duration between put-in and reperfusion of the graft by employing arterialization of the portal vein (APV) for the vascular reconstruction of the recipient.

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The present paper is the first to report on the clinical application of the APV technique for vascular reconstruction in partial liver transplantation cases using grafts from living related donors. A case which was rescued by emergency use of APV is also reported.

Materials and methods

Fourteen pediatric cases of partial liver transplantation using liver grafts obtained from related living donors (either from the father or mother) were performed at the Second Department of Surgery, Kyoto University Hospital from June 1990 to March 1991. As shown in the summary of patient profiles in Table 1, there were 11 cases of biliary atresia, two of Budd-Chiari syndrome, and one of liver cirrhosis after blood transfusion for a previous hepatectomy for hepatoblastoma. The ages ranged from 8 months to 11 years old; there were seven boys and seven girls. The operations were elective in 11 cases, and emergency in three.

Figure 1 shows the procedure used for the arterialization of the portal vein. The procedure was employed in the first three cases. Venous grafts were dissected in each donor; the great saphenous vein in case 1, the ovarian vein in case 2 and the inframesenteric vein (IMV) in case 3. These venous grafts were anastomosed to the portal vein of the liver grafts on the back-table prior to put-in of the graft. After the anastomosis of the hepatic vein, the portal vein of the graft was connected to a heparin-coated silicon catheter (4 mm in external and 3 mm in internal diameter), the other end of which was already inserted into the right femoral artery. The liver graft was perfused by arterial blood through this catheter. During APV, hepatic arterial reconstruction was performed. The portal vein was reconstructed by usual anastomosis techniques after arterial revascularization.

Arterial blood ketone body ratio, reflecting the mitochondrial redox state, was measured enzymatically by autoanalyzer using a commercially available kit (Ketorex) during and after operation [12].

Results

Figure 2 shows the times required for vascular reconstruction. APV was employed in cases 1, 2, and 3. In cases 4–7, vascular reconstructions were performed in the usual order, namely, hepatic vein, portal vein, revascularization

Table 1. Summary of data for patients who underwent partial liver transplantation. APV, Arterialization of portal vein; CBA, congenital biliary atresia; POD, postoperative day; IMV, inferior mesenteric vein; IVC, inferior vena cava

Case no.	Age	Sex	Primary disease	Elected/emergency operation	APV[a]	Outcome
1	9 y	M	CBA	Elective	+ (Sahpenous)	Died of asphyxia (179th POD)
2	3 y	M	CBA	Elective	+ (Ovarian)	Alive
3	9 y	F	CBA	Elective	+ (IMV)	Alive
4	3 y	M	Budd-Chiari syndrome	Elective	–	Alive
5	9 y	M	Cirrhosis, post-op. state of hepatoblastoma	Emergency	+ (IVC)	Died of heart failure (25th POD)
6	11 m	F	CBA	Emergency	–	Alive
7	6 y	M	CBA	Elective	–	Alive
8	11 y	M	Budd-Chiari syndrome	Emergency	–	Died of resp. failure renal failure (21st POD)
9	15 m	F	CBA	Elective	–	Alive
10	8 m	M	CBA	Elective	–	Alive
11	8 m	F	CBA	Elective	–	Alive
12	13 m	F	CBA	Elective	–	Alive
13	5 y	F	CBA	Elective	–	Alive
14	2 y	F	CBA	Elective	–	Alive

[a] Venous graft used

of the grafts, and then hepatic artery. In case 5, the anastomosed portal vein was tapered and the portal vein was reanastomosed. At reflow, bleeding from the anastomosis site was detected. At this point 74 min had already elapsed after put-in of the graft. Prior to the reanastomosis of the portal vein, an emergency APV had to be done in order to minimize the warm ischemic injury to the graft. The duration of this emergency APV procedure was 25 min, during which time the hepatic artery was reconstructed. After that, the infrarenal inferior vena cava of the recipient was dissected for a venous graft for portal vein. Portal reanastomosis required 28 min. The total duration from the put-in to the final reflow of the graft was 127 min. In cases 8–14, a surgical microscope was used for the hepatic artery reconstruction. In case 11, the hepatic arteries branching individually to segments 2 and 3 were individually anastomosed.

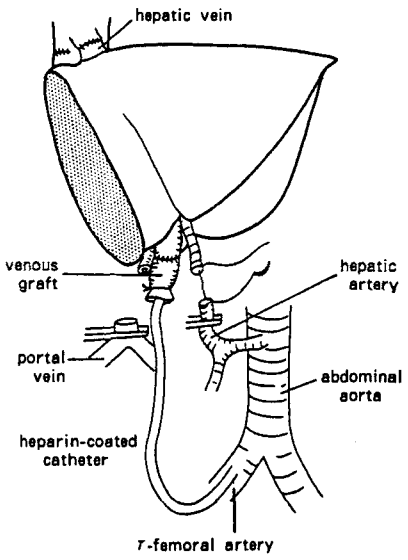

Fig. 1. Procedure for arterialization of the hepatic portal vein

Table 2 shows the differences in the time lapse between put-in and reperfusion of the graft. In the cases in which APV was employed, the mean time was only about 25 min. In cases 4, 6, and 7, the mean time from put-in to reperfusion of the graft after the end of portal anastomosis was over 50 min, which was twice as long as in the cases with APV. By contrast, in the most recent eight cases, the mean time lapse was only 33 min, which was almost as short as in the cases with APV.

Figure 3 shows the time required for arterial blood ketone body ratio (KBR) to initially recover to the normal range of over 1.0 after revascularization of the grafts. KBR values at the end of the anhepatic phase ranged from 0.20 to 0.59 (mean value: 0.38) in these 14 cases. In 11 of the 14 cases, KBR recovered to over 1.0 within 24 h; in four recently operated cases, it recovered immediately after revascularization within 4 h. In the cases in which APV was employed, the KBR tended to recover more slowly than in those in which the usual reconstruction method was followed. In cases 8 and 10, in which the KBR took 48 h to recover to over 1.0, massive hemorrhage from the inferior vena cava occurred during the adhesiolysis of the liver, and systemic arterial pressure could not be maintained over 80 mmHg during the operation despite massive blood transfusion.

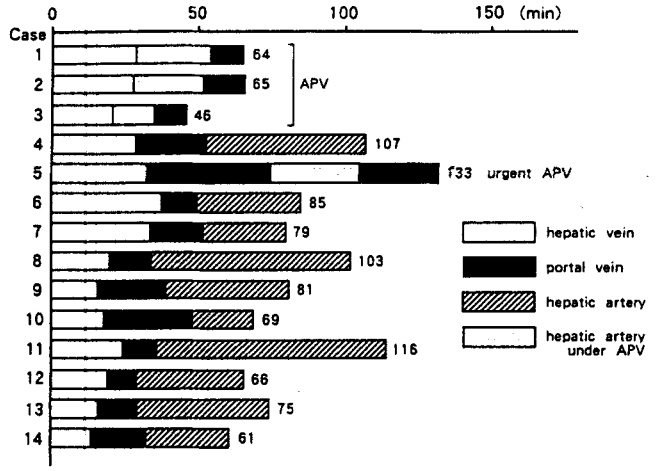

Fig. 2. Time required for vascular reconstruction in the 14 cases of partial liver transplantation

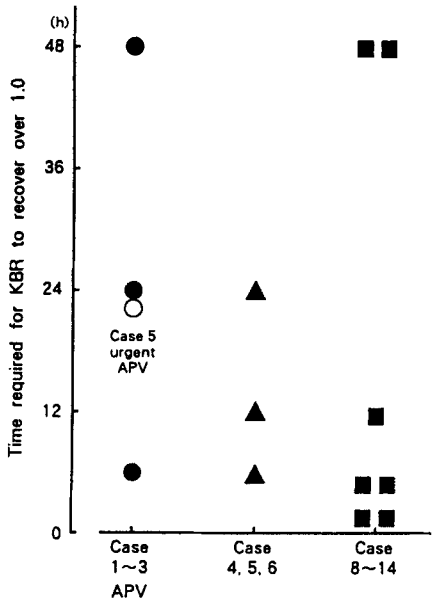

Fig. 3. Time required for initial recovery of arterial blood ketone body ratio (KBR) to over 1.0

Discussion

It is widely accepted that the ischemic phase of the grafts and the period between put-in and reperfusion of the grafts should be made as short as possible. A delay in the revascularization of the grafts causes not only an increase in the graft temperature, followed by warm ischemia and deterioration of the cellular viability of the grafts, but also a prolongation of the anhepatic phase, resulting in the dangerous accumulation of toxic metabolites in the recipients. Under such circumstances, retransplantation might often be required due to the poor initial functioning of the grafts.

In order to avoid the prolongation of the ischemic phase as well as some of the hazards mentioned above, we used APV in our first few experiences of clinical partial liver transplantation. Sheil et al. [6], reporting on their clinical experience of APV in whole liver transplantation, have pointed some advantages of this method. Prior to our clinical trial, we performed extensive experiments on dogs to investigate the advantages of APV. The results from these preliminary experimental studies have indicated that the volume of arterial blood flow through the APV catheter is enough to maintain the function even of the whole liver [13, 14], and the functional recovery of the transplanted graft in partial liver transplants with APV occurred more immediately than in those without APV [3]. Indeed, the results obtained from the present clinical study show that the duration of the ischemic phase after put-in of the grafts could be greatly shortened by the practice of APV, which would also relieve the time constraints on the surgeons. However, as a result of the experience we have gained, the time required for vascular reconstruction has been shortened, especially in the recent cases, making it now unnecessary to use APV to reduce the ischemic phase. In addition since portal blood contains certain hepatotropic factors such as insulin, and since perfusion by portal blood is more physiological for the grafts, it is conjectured that it is better for the transplanted grafts to be directly perfused by portal blood as soon as possible, rather than by arterial blood, especially from the viewpoint of liver regeneration. In fact, the recovery of KBR after revascularization of the grafts, which has been demonstrated experimentally and clinically to be essential for successful implant of the liver grafts [1, 4, 5, 8–11, 15], occurred more immediately in some cases with usual vascular reconstruction than those with APV. In these cases, along with rapid recovery of KBR, the mitochondria of the transplanted grafts started to function immediately after revascularization, to produce the energy essential to drive the many cellular functions of the graft, resulting in successful liver transplantation.

The present clinical study suggests that, while the APV procedure may seem unnecessary for the practised surgeon, there are many cases where complications occur, especially in connection with portal anastomosis due to bending, distortion, tapering, obstruction, bleeding and so on, as encountered in case 5 of our experience. In such cases, the carrying out of an emergency APV is useful to prevent prolongation of the warm ischemic phase of the grafts. We invariably prepared for APV even in the recent, uneventful cases. Although the procedure is of limited advantage, an emergency APV can rescue the grafts if some trouble occurs.

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Table 2. Time lapse between put-in and reperfusion of the graft (min) in 14 cases. APV, Arterialization of portal vein. Values are expressed as means ± SD

APV employed (cases 1–3)	Urgent APV (Case 5)	Usual anastomosis	
		1990 (Cases 4, 6, 7)	1991 (Cases 8–14)
25.7 ± 3.3	74.0	51.0 ± 1.4	33.0 ± 3.9

nical assistance in the precise measurement of acetoacetate and 3-hydroxybutyrate (ketone bodies).

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