Division of Donor Liver for Successful Split-Liver Transplantation in Pigs

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Abstract: Split Liver Transplantation (SLT) is an attractive method to solve the problem of a shortage of liver grafts. A through knowledge of the anatomy of the porcine liver vessels and bile duct is essential in performing the experimental SLT. This study was undertaken to decide the split line for successful SLT in pigs by examining the main branching patterns both vessels and bile duct in 30 porcine livers macroscopically and angiographically. The hepatic arterial branching patterns were divided into three types and bile duct patterns into two types. There was no exception in branching patterns of the portal vein and the hepatic vein. We conclude it is desirable that the donor liver should be divided into two grafts between the left medial lobe and quadrate lobe.

Key words: porcine liver, split line, split liver transplantation

Liver transplantation, established as a method to save patients falling in the last stage of liver failure, is carried out nearly a thousand times every year throughout the world. But at present, because liver transplantation has increased, the shortage of liver grafts throughout the world has become a serious problem. Split liver transplantation (SLT), two grafts obtained from one donor being used for two recipients, is considered as an expedient to solve this problem. The clinical SLT were done before [1, 5, 9, 10], but there were no reports on animal experiments until we carried out SLT on pigs [13], which have some anatomical and physiological similarities to human beings [2, 6, 7, 11, 14]. In future, experimental adult-to-adult SLT on pigs will increase as human. In SLT on pigs, operators have to be well aware of the liver anatomy of both vessels and bile duct. The aim of the present study is to clarify the main branching patterns of the portal vein, hepatic artery, hepatic vein and bile duct and to decide on the split line in the porcine liver, presupposing SLT.

Thirty livers removed from Large White strain pigs weighing 20–25 kg were used in this experiment. After removal of the liver, catheters were placed in the common bile duct, the hepatic artery and portal vein at the hepatic porta. Latexes colored white and red were injected through catheters placed in the hepatic artery and bile duct respectively, to examine their branching patterns. The distribution of the portal and hepatic vein were examined by angiography.

[Hepatic artery] The hepatic artery forked into three
main arteries in the porcine liver. The first artery branched toward both the left lateral lobe [LLL: *Lobus hepatis sinister lateralis*] and left medial lobe [LML: *Lobus hepatis sinister mediaalis*] (left branch: *Ramus sinister*), the second ran to the quadrate lobe [QL: *Lobus quadratus*] and right medial lobe [RML: *Lobus hepatis dexter mediaalis*] (right medial branch: *Ramus dexter mediaalis*) and the third branched to the right lateral lobe [RLL: *Lobus hepatis dexter lateralis*] and caudate lobe [CL: *Lobus caudatus*] (right lateral branch: *Ramus dexter lateralis*). The intrahepatic branching patterns of the hepatic artery were divided into three types (Fig. 1). The first type was a pattern in which the three main arteries branched from the same portion of the intrahepatic trunk (TYPE 1: 9/30). In the second type the right branch ramified first and other vessels branched off the same portion of the intrahepatic trunk (TYPE 2: 7/30). In the third type the small branch to CL (A. *lobi caudati*) branched independently from the hepatic artery at the *hilus* and then other vessels were distributed similarly to TYPE 1 (TYPE 3: 14/30).

[Portal vein] In thirty porcine livers, there were no variations in the intrahepatic portal branching patterns. The portal trunk came into the liver at the *hilus* and branched to the CL and RLL (right branch: *Ramus dexter*) first. Then the portal vein made a sweeping curve to the left lobe called the "horizontal portion" in human beings and branched to the RML, QL, LLL and LML (left branch: *Ramus sinister*) (Fig. 2).

[Bile duct] There were two types in the branching patterns of the bile duct in porcine livers (Fig. 3). In one type the branch from the CL and RLL joined the right hepatic duct (*Ductus hepaticus dexter*) (TYPE 1: 9/30) and in another it made a detour and joined the left hepatic duct (*Ductus hepaticus lateralis*) (TYPE 2: 21/30) (Fig. 4). The junction of the duct from the CL and RLL leading into the left hepatic duct was located about 1.5–2 cm distal from the divergent point of the cystic duct.

[Hepatic vein] There are three main hepatic veins in the porcine liver. The first is the branch called the "left hepatic vein" draining from the LLL and LML (V. *hepatica sinister*), the second called the "middle hepatic vein" is from the gall bladder, LML and QL (V. *hepatica media*), and the third called the "right hepatic vein" from the RLL, RML and CL (V. *hepatica dextra*)
(Fig. 5). There were no anomalies in the branching patterns in the porcine hepatic vein.

As pigs have frequently been used for experimental liver transplantation [3, 4, 8, 12], we considered that they would be useful experimental animals for split liver transplantation too. In dividing the porcine liver, we must pay attention to the following: (1) divide the liver equally by weight, (2) enable the operator to anastomose the vessels at the section, (3) avoid congestions of blood and bile caused by the division. From this study, operators should take particular notice of the transactions on the bile duct and hepatic vein. The bile duct considered TYPE2 was transected more than 2 cm distal from the point of divergence of the cystic duct in the left medial segment. The hepatic vein should be divided at the right side of middle hepatic vein that drains large quantities from the LML rather than from QL (Fig. 5).

For the above reasons, the authors propose that the donor liver for successful SLT in pigs should be divided into two grafts between the LML and QL. In this section, mean diameters of the portal vein, hepatic artery, hepatic vein and bile duct were 10 mm, 3 mm, 12 mm and 2 mm, respectively, and the operator would be able to anastomose their vessels and bile duct. The grafts obtained from the division are of almost equal weight (left graft: 47%, right graft: 53% of the whole weight) and they have been successfully transplanted into two pig recipients [13].

References