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Case Report

An 82-year-old recipient of split liver transplantation worldwide: A case report

Xiao Feng [a, 1], Binsheng Fu [a, 1], Qing Yang [a], Kaining Zeng [a], Huimin Yi [b, *], Shuhong Yi [a, **], Yang Yang [a, ***]

[a] Department of Hepatic Surgery and Liver Transplantation Center, The Third Affiliated Hospital of Sun Yat-sen University, Guangzhou, Guangdong, China
[b] Surgical Intensive Care Unit, The Third Affiliated Hospital of Sun Yat-sen University, Guangzhou, Guangdong, China

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ABSTRACT

Split liver transplantation (SLT) has become an indispensable method for expanding the donor liver pool. However, advanced age in recipients can have significant adverse effects on prognosis. We report the case of an 82-year-old man with chronic liver failure and polycystic liver disease who underwent *in vivo* split right triple lobe donor liver transplantation on October 29, 2021. The patient made a remarkable recovery and was discharged 1 month after surgery. To date, he has been followed up for 32 months, with favorable laboratory and imaging test results, and no significant abnormalities or complications. Currently, this patient may be the oldest SLT recipient in the world. With comprehensive preoperative evaluation, optimized surgical techniques, and individually tailored postoperative care, older adults can safely undergo SLT. Therefore, advanced age should not be considered an absolute contraindication for this procedure.

1. Introduction

Split liver transplantation (SLT) has emerged as a crucial approach to increase the availability of donor livers. Nonetheless, the advanced age of recipients can pose substantial challenges to their prognosis. We present the case of an 82-year-old man with chronic liver failure and polycystic liver disease who underwent *in vivo* split right triple lobe donor liver transplantation on October 29, 2021. The patient recovered well and was discharged 1 month after the operation. To date, he has been followed up for 32 months, showing positive results in laboratory and imaging tests, without any significant abnormalities or complications. This case may represent one of the oldest individuals to receive SLT worldwide. We believe that it is possible for older adults to receive SLT safely with comprehensive preoperative evaluation, optimized surgical procedure, and tailored postoperative management. Therefore, old age is not an absolute contraindication to SLT.

2. Case presentation

This study complies with the Declaration of Helsinki and the Declaration of Istanbul and was approved by the Ethics Committee of the Third Affiliated Hospital of Sun Yat-sen University (Approval No. CR2024-020-01). The patient provided written informed consent for the surgical procedure, data review, publication, and inclusion in this study.

The transplant recipient was an 82-year-old man who weighed 65 kg. He was admitted to our facility on August 8, 2021, with recurrent abdominal pain with jaundice and scleral icterus for more than 20 years. The patient had a medical history of hypertension and coronary artery disease, both of which had been present for more than 20 years. He was receiving long-term pharmacotherapy (The oral medications include Nifedipine 30 mg once daily, Irbesartan 150 mg once daily, Bisoprolol 5 mg once daily, and

* Corresponding author. Surgical Intensive Care Unit, The Third Affiliated Hospital of Sun Yat-sen University, Guangzhou, Guangdong, China.
** Corresponding author. Department of Hepatic Surgery and Liver Transplantation Center, The Third Affiliated Hospital of Sun Yat-sen University, Guangzhou, Guangdong, China.
*** Corresponding author. Department of Hepatic Surgery and Liver Transplantation Center, The Third Affiliated Hospital of Sun Yat-sen University, Guangzhou, Guangdong, China.
E-mail addresses: ylhmin@hotmail.com (Huimin Yi), yishuhong@163.com (Shuhong Yi), yysysu@163.com (Yang Yang).
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[1] These authors contributed equally to this work.

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Clopidogrel 75 mg once daily) for both conditions. Upon examination, he exhibited yellowing of the skin and sclera, and a distended abdomen. The liver was palpable 7 cm below the right costal margin. The patient subsequently underwent an extensive evaluation, including assessments of cardiovascular, respiratory, and renal functions. Laboratory tests revealed elevated levels of aspartate transaminase (AST) and alanine transaminase (ALT), measuring 99 U/L and 77 U/L, respectively. Albumin levels were decreased to 29 g/L, while total bilirubin was elevated at 283 μmol/L. Platelet count (200 × 10^9/L), creatinine level (73 μmol/L), and serum glomerular filtration rate (82%) were all within normal ranges. Prothrombin time was slightly prolonged at 14.6 seconds. The patient was classified under Child-Pugh class C. Moreover, an abdominal computed tomography (CT) examination (Fig. 1) revealed polycystic liver disease, polycystic kidney disease, and moderate dilation of the intrahepatic bile ducts.

The diagnostic considerations included chronic liver failure, polycystic liver disease, and polycystic kidney disease. Cervical vascular ultrasound, coronary CT angiography, color Doppler echocardiography, electrocardiogram, and chest CT scan were performed, None of the tests showed strict contraindications to liver transplantation. Lung function assessment confirmed mild restrictive ventilatory dysfunction. The patient's daily activities were limited by his condition. He exhibited Class I cardiac function according to the New York Heart Association (NYHA) Functional Classification and was assigned the American Society of Anesthesiologists (ASA) Class III anesthesia grade.

Surgical data: A comprehensive examination of the patient confirmed that there were no surgical contraindications, SLT was performed on October 29, 2021. The donor was a 15-year-old male (height:168 cm; weight: 55 kg) who had passed away due to traumatic brain injury and brain herniation. Organ donation was performed on him after his parents provided written informed consent. He was fully compliant with the required donation process in accordance with China's rules on human organ donation and transplantation for minors and was registered with the China Organ Transplant Response System (https://www.cot.org.cn/). To minimize cold ischemia time, we carefully coordinated between the donor and recipient surgical teams. The donor's liver was split *in vivo* into a right triple lobe, which weighed 840 g and had a graft-to-recipient weight ratio (GRWR) of 1.29%. The modified piggyback technique was employed for the anastomosis of the vena cava. Details of the two recipients are shown in Table 1, and photographs of the donor livers are presented in Fig. 2. The diseased liver is depicted in Fig. 3.

Postoperative maintenance: Postoperatively, the patient was transferred to our facility's intensive care unit (ICU). There, he was closely monitored for graft function, circulatory status, and the major organ function. The patient was transferred back to a general ward on the postoperative day 4, on the proviso that his condition remained stable and there were no adverse or unexpected medical events. His postoperative liver function recovery was favorable (Fig. 4), and postoperative follow-up imaging performed two weeks after surgery showed satisfactory liver volume growth (Fig. 5). The patient was successfully discharged from the hospital 1 month after the operation (November 29, 2021). The pathology of the diseased liver was consistent with the changes in polycystic liver disease.

The patient suffered no severe side effects from drugs or surgical complications that occurred during the postoperative follow-up period. For immunosuppression, low-dose tacrolimus (0.5 mg bid; Astellas Pharma Inc., Toyama, Japan) monotherapy was administered orally to avoid excessive immunosuppression or renal impairment (Fig. 6). This treatment was continued for the first 6 months after discharge. The dose of tacrolimus was then increased to 1 mg bid, and mycophenolate mofetil (180 mg bid; Novartis, Basel, Switzerland) was added because of a mild elevation in the patient's liver function. Thus far, the patient has been followed up for 32 months and has shown a favorable prognosis.

3. Discussion

Liver transplantation is limited by a shortage of donors. Many patients lose the opportunity for transplantation because a suitable liver cannot be found in time.[1,2] SLT is an innovative expansion of surgical techniques that effectively increases the number of donor livers, and reduces organ shortages.[3,4] However, the perioperative period in SLT carries many risks and these can lead to surgical failure or even the death of the recipient.

The advanced age of the recipient is an independent risk factor for the increase in perioperative morbidity and mortality.[5] However, most transplant centers do not have strict age limits for liver transplant eligibility and tend to emphasize biological age over chronological age.[6] The 2013 Adult Liver Transplantation Evaluation Guidelines of the American Association for the Study of Liver Diseases suggest that, in the absence of significant comorbidities, advanced age >70 years should not be considered an absolute contraindication for liver transplantation.[7] Good outcomes of liver transplantation in older recipients have also been reported in clinical practice, including findings from single-center studies and registry data analyses.[8,9] However, the perioperative period carries

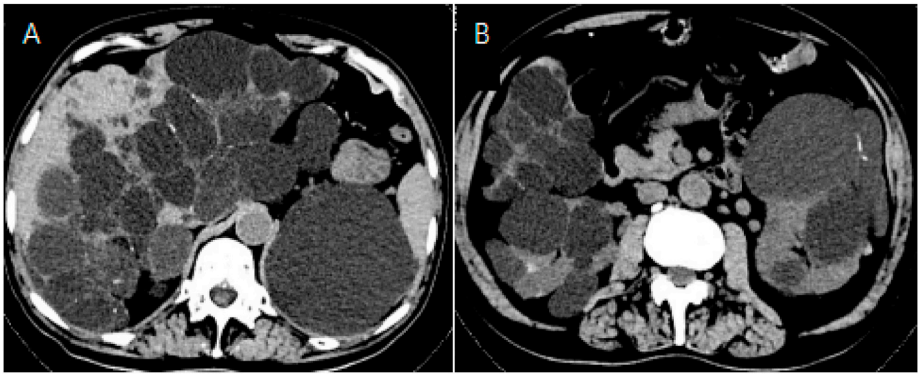

Fig. 1. Preoperative computed tomography scan of the transplant recipient's abdomen. (A) The liver is enlarged, with a rough surface, moderate dilation of intrahepatic bile ducts, and widened hepatic fissures. Multiple round hypodense shadows are visible, with calcifications noted in some of the cystic walls. **(B)** Multiple round hypodense shadows are visible in both kidneys.

Table 1
Clinical and demographic characteristics of the older and pediatric liver transplantation recipients.

Characteristics	Older recipient	Pediatric recipient
Age	82 years	9 months
Weight (kg)	65	8
Type of liver donor	Right triple lobe	Left lateral lobe with volume reduction
Weight of donor liver (g)	840	280
GRWR (%)	1.29	3.50
Vena cava anastomosis	Modified piggyback	Modified piggyback
Portal vein anastomosis	Continuous end-to-end anastomosis of donor–recipient portal vein trunk	Donor portal vein left branch–recipient portal vein trunk continuous end-to-end anastomosis
Hepatic artery anastomosis	Continuous end-to-end anastomosis of the donor common hepatic-splenic artery confluence with the recipient's right and left hepatic arteries	Donor left hepatic artery–recipient right hepatic artery end-to-end interrupted anastomosis
Biliary anastomosis method	Posterior wall continuous anastomosis and anterior wall interrupted end-to-end anastomosis	Roux-en-Y biliary-intestinal anastomosis
Length of surgery (min)	380	588
Intraoperative blood loss volume (mL)	500	150
Liver-free period (min)	31	96
Cold ischemia time (min)	365	379

Abbreviation: GRWR, graft and recipient weight ratio.

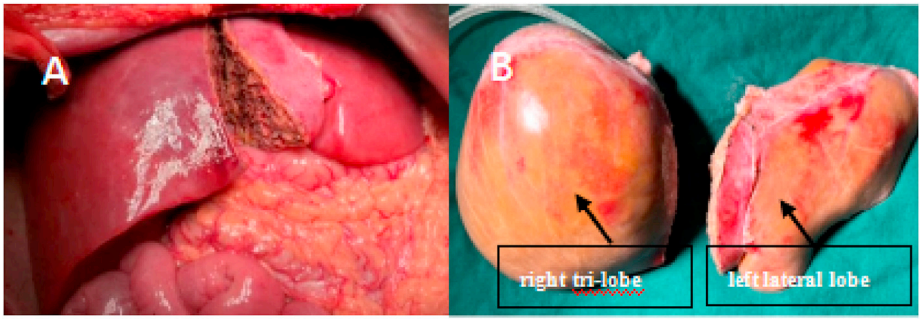

Fig. 2. *In vitro* split donor liver during and after harvesting. (A) *In vitro* split donor liver had a soft texture, reddish color, and clearly defined edges; **(B)** Schematic of the donor liver after *in vivo* splitting. The *in vivo* split right tri-lobe graft (shown on the left side of image B) was transplanted into our patient. The *in vivo* split left lateral lobe graft (shown on the right side of image B) was transplanted into the other recipient.

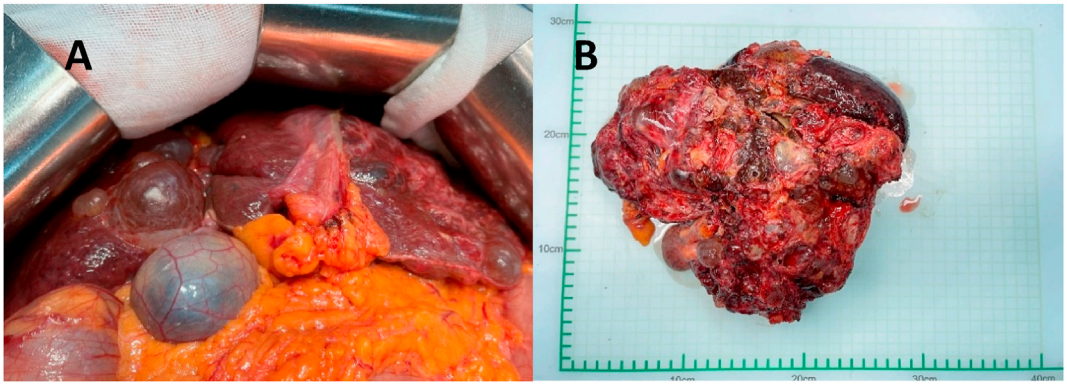

Fig. 3. Diseased livers of the 82-year-old transplantation recipient during surgery and after harvesting. (A) *In vivo* diseased liver. **(B)** *Ex vivo* diseased liver. This was significantly enlarged, tough, and covered with round-like cystic cavities of varying sizes, but without obvious cirrhosis.

more risks for older recipients, with a higher probability of serious complications.[10] These can lead to wastage of the donor liver and recipient death.

Therefore, the evaluation of the suitability of older recipients for SLT should be stringent. Comprehensive control should be exercised to maximize older recipient safety. First, a rigorous preoperative medical assessment of the recipient should be performed, including tests of cardiorespiratory reserve, renal function, and nutritional status to exclude these surgical contraindications.[5] Furthermore, preoperative assessment should identify any vascular in older recipients, preferably using cervical vascular ultrasound. Once older recipients are approved for transplantation, surgical procedures should be optimized, to minimize the cold ischemia time of the donor liver and reduce bleeding. The *in vivo* splitting surgical way of harvesting the donor liver should be used.[11] Anatomical assessment of the donor liver and the measurement of its volume can be performed using preoperative imaging and during harvesting. To further control the cold ischemia time of the donor liver and minimize the liver-free period, the donor liver harvesting team, surgical team, and anesthesia care

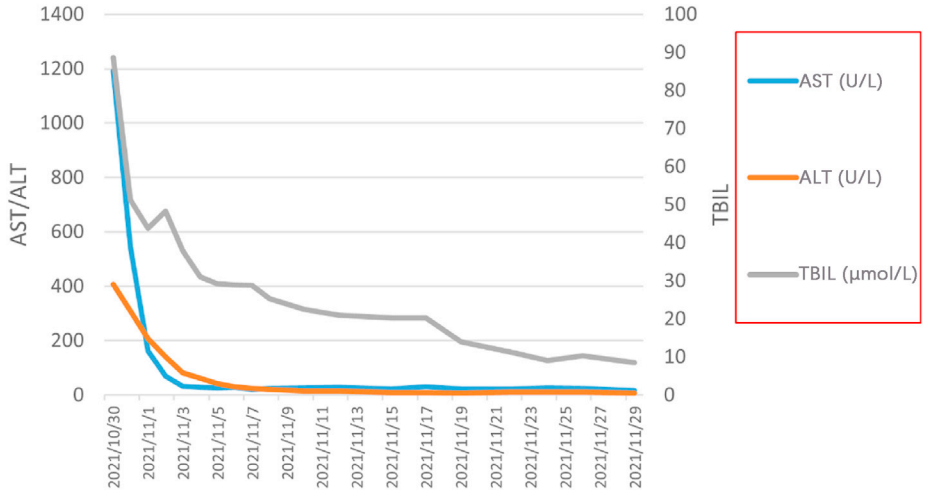

Fig. 4. Patient's transaminase and bilirubin levels over the course of the first month after surgery. Transaminase and bilirubin levels rapidly increased in the first few days after transplantation, but transaminase returned to normal within the first postoperative week. Abbreviations: ALT, alanine transaminase; AST, aspartate transaminase; TBIL, total bilirubin.

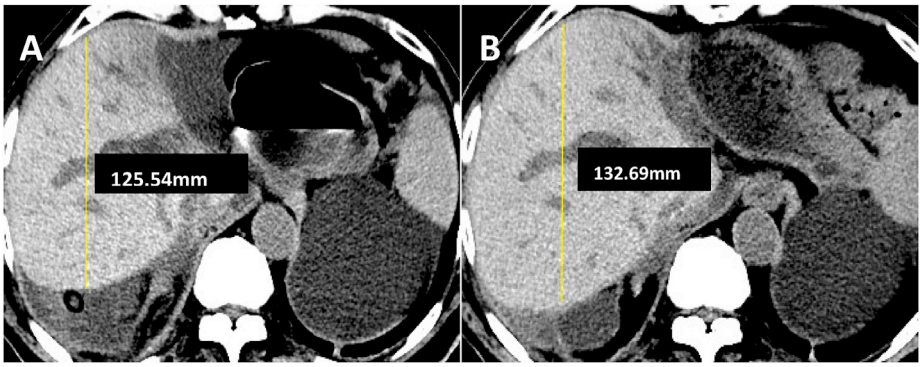

Fig. 5. Postoperative abdominal computed tomography of the graft. On postoperative day 14 **(B)**, computed tomography revealed a 5.6% increase in liver volume compared to postoperative day 7**(A)**, indicating satisfactory liver growth.

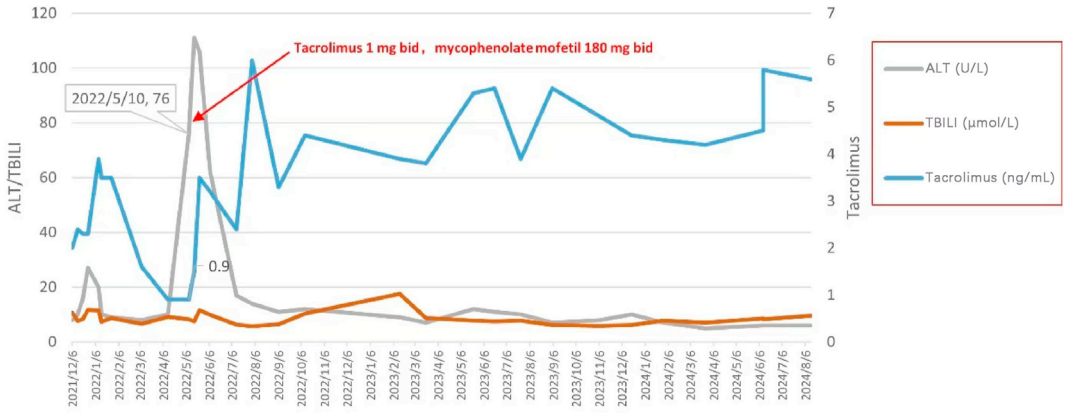

Fig. 6. Fluctuations in the recipient's liver function and tacrolimus concentrations postdischarge over 32 months. After discharge from the hospital, the patient's liver function remained stable, with low blood concentrations of tacrolimus consistently maintained. This stability was subsequently maintained by increasing the tacrolimus dose, and mycophenolate mofetil was added to the patient's treatment in response to fluctuations in liver function (On May 10, 2022, transaminase levels were elevated to 76 U/L, and the tacrolimus concentration was 0.9 ng/mL). Abbreviations: ALT, alanine transaminase; TBILI, total bilirubin.

team must maintain closer communication and coordination. For postoperative maintenance, transplant centers should have well-qualified and trained professional intensive care teams that are able to closely monitor the function of the transplanted liver, heart, lungs, kidneys, other major organs, and the transplanted liver. Moreover, recipients should be closely followed up after discharge to ensure mid- and long-term graft function. As the immunity of older recipients is usually lower, we recommend lower doses of

immunosuppressants,[5] regular laboratory tests and imaging, and adjustment of the type and dosage of immunosuppressants according to the test and imaging. This will help to avoid any adverse drug effects or irreversible rejection reactions.

Despite the encouraging findings, this study has several limitations that should be acknowledged. First, this is a case report, which inherently limits the generalizability of the results. Future studies with larger cohorts are necessary to validate these outcomes. Second, the study was conducted at a single center, multicenter studies could enhance the external validity of the results. Lastly, the follow-up period may not be sufficient to fully assess long-term graft function and patient survival, highlighting the need for extended monitoring in future research.

4. Conclusions

Safe and effective SLT is possible among older transplant recipients. To improve quality of life and increase long-term survival, this patient population requires comprehensive preoperative evaluation, optimized surgical procedures, and individually tailored postoperative management.

Authors' contributions

Xiao Feng and Binsheng Fu contributed equally to this work and should be considered co-first authors. **Xiao Feng:** Writing – review & editing, Writing – original draft, Funding acquisition. **Binsheng Fu:** Writing – review & editing. **Qing Yang:** Resources. **Kaining Zeng:** Resources. **Huimin Yi:** Resources. **Shuhong Yi:** Supervision. **Yang Yang:** Supervision. All authors have read and approved the final manuscript.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Declaration of competing interest

Yang Yang is an executive associate editor for *Liver Research* and was not involved in the editorial review or the decision to publish this article. All authors declare that there are no competing interests.

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