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Research Letter

Heterotopic Auxiliary Liver Transplantation in a Child with Portal Hypertension Using a Discarded Partial Right Liver Allograft from an Adult Patient with Alveolar Echinococcosis

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Auxiliary partial liver transplantation (LT) involves implanting a functional partial graft from a discarded liver segment to supplement the native liver, offering an alternative for patients ineligible for standard LT.[1–4] Currently, most discarded allografts are derived from benign left-lobe lesions (e.g., cavernous hemangioma or focal nodular hyperplasia [FNH])[5–7] and are obtained from the left rather than the right liver lobes because the left lobes' anatomy is simpler and easier to reconstruct *in vitro*.[8,9] However, this approach results in the loss of many potentially functional allografts from the right hepatic lobes. Grafts from patients with cystic echinococcosis (CE) have previously been used for whole-LT (Supplementary Table 1); however, grafts from patients with hepatic alveolar echinococcosis (AE)—a parasitic disease with infiltrative growth and higher morbidity[10]—have not yet been explored as allograft sources for heterotopic auxiliary LT.

We present the first case of heterotopic auxiliary LT using a discarded partial right-lobe allograft from an AE patient for a critically ill girl with portal hypertension (PHT) who lacked access to a suitable liver graft. The graft (232 mL) was anastomosed to splenic vessels following splenectomy. The AE donor recovered uneventfully. The recipient had normal graft function (volume increased to 443 mL) and tested negative for anti-*Echinococcus* IgG at the 12-month follow-up. In this report, we examine the technical feasibility of using allografts from patients with AE, thereby evaluating a previously unreported source of discarded grafts in urgent pediatric LT.

Clinical features and preoperative planning

A five-year-old girl was admitted with a history of hematemesis for about three years, along with clinical evidence of anemia and splenomegaly. Laboratory tests revealed hemoglobin of 61 g/L (normal range: 112–149 g/L) and a platelet count of 81 × 10^9/L (normal range: 188–472 × 10^9/L). Contrast-enhanced computed tomography (CT) showed PHT, splenomegaly, ascites with portal cavernoma, grossly dilated esophageal/gastric fundal varices, and replacement of the main portal vein (PV) duct by collateral vessels (Fig. 1, A2-D2). There was no similar medical history in her family. The patient weighed 18 kg and had been awaiting LT without the availability of suitable liver graft donors.

A 34-year-old male was subsequently admitted with hepatic AE. CT imaging revealed a heterogeneous low-density mass (size: 9 × 10 cm) in the right hepatic lobe, adjacent to the sagittal portion of the left PV. The AE mass occupied segments 1, 5, 6, 7, 8, and 4b (Fig. 1, A1-D1). However, the anatomic location and relative sparing of segment 6 indicated that this portion could be reconstructed to serve as a functional lobe *in vitro* (yielding a liver volume of approximately 257 mL) (Fig. 1, A1, white arrow). Based on our prior experience with auxiliary autologous LT, we considered using this discarded liver segment for heterotopic auxiliary LT. The blood types of both patients matched. Both the donor hepatectomy and graft procurement protocols were approved by the Ethics Committee of Sichuan Provincial People's Hospital, and informed consent was obtained from both patients.

Operative procedure for donor and recipient

For the patient with PHT, orthotopic LT was unrealistic because of organ shortage and the presence of portal cavernoma, which complicates PV reconstruction. A splenorenal shunt is a selective surgery for relieving PHT; however, this

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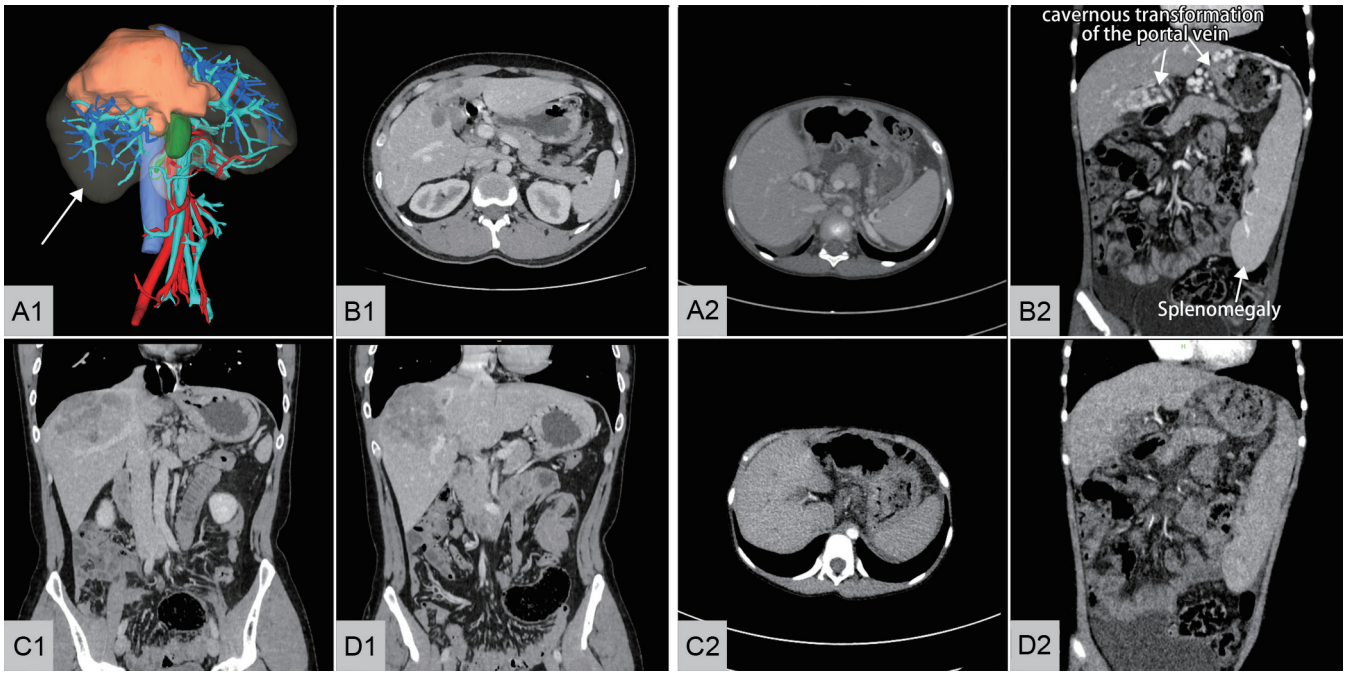

Fig. 1. The enhanced CT scan and 3D model of the two patients. (A1-D1) The enhanced CT scan of the hepatic AE patient (A1: the 3D model of the CT images; B1: coronal position/venous phase; C1: sagittal position/venous phase; D1: sagittal position/arterial phase). (A2–D2) The enhanced CT scan of the girl with PV cavernous transformation and portal hypertension (A2: coronal position/venous phase; B2: sagittal position/venous phase; C2: coronal position/arterial phase; D2: sagittal position/arterial phase). CT, computed tomography; AE, alveolar echinococcosis; 3D, three-dimensional; PV, portal vein.

procedure is associated with sequelae such as PV thrombosis, ascites, and encephalopathy.[11] Under these conditions, the ideal choice is a surgical technique that preserves native hepatic function while also relieving PHT.

Recently, Ravaioli *et al*. employed a technique of heterotopic segmental LT using splenic vessels after splenectomy in pediatric PHT patients.[9] Unlike their cases, our patient did not require delayed native hepatectomy, which is typically needed in patients with normal hepatic function. Furthermore, this heterotopic segmental LT could relieve PHT similarly to a splenorenal shunt while also preserving native hepatic function.

The final surgical plan was developed for both patients. For the patient with hepatic AE, a right hemi-hepatectomy with partial resection of segment 4b was planned. After resecting the right hemiliver, it was transferred to an ice table for cold University of Wisconsin solution perfusion and AE mass resection. After the AE mass was removed, the remnant portion of segment 6 was repaired to serve as a functional lobe, which was then transplanted into the recipient's splenic vessels following splenectomy. The surgical protocol was approved by the Ethics Committee of Sichuan Provincial People's Hospital.

Literature review

Our review of the literature revealed no reports on the use of discarded hepatic allografts after resection for AE. However, there are reports of LT using grafts obtained during mass resection for CE (Supplementary Table 1). In that study, the postoperative recurrence rate for CE-derived grafts was 25% (1/4). The invasive nature of AE suggests that, theoretically, the recurrence risk may be higher. Nevertheless, the absence of recurrence in that study was attributed to (1) intraoperatively confirmed negative resection margins; (2) postoperative maintenance of an albendazole regimen; and (3) the relatively short follow-up duration.

Operative technique

Based on the principle of "*in situ first*",[7] the hepatic parenchyma was split, and the right PV, right hepatic artery, and right hepatic vein (HV) were exposed, with segment 6 isolated (Fig. 2A). Intraoperative ultrasound confirmed that the liver graft was free of AE, with resection margins of >1 cm from the lesion. Once the liver parenchyma was exposed to the invaded HV and PV branches, the right half of the liver was removed and placed into an ice bath. The graft was then gravity-perfused via the PV with 4°C pre-cooled University of Wisconsin solution for further bench resection (Fig. 2B). A functional segment 6 was reconstructed (Fig. 2C), yielding a liver graft weighing 232 g.

For the recipient, the branches of the splenic vessels were dissected and clamped, and the spleen was removed. The left renal vein (LRV) was dissected, and the graft was placed in the splenic fossa. The graft was implanted with an end-to-end anastomosis between the splenic vein (SV) and PV, ensuring the anastomotic site was tension-free and without torsion. Once the SV-PV inflow was established, the HV branches and LRV were anastomosed to the inferior vena cava, ensuring sufficient width and patency of the outflow tract. After completing the HV-LRV end-to-end anastomosis, the allograft was perfused by opening the SV-PV inflow. The surgery was completed with end-to-end anastomosis of the splenic artery to the hepatic artery and biliary anastomosis (choledochojejunostomy) (Fig. 2D). Following vascular reconstruction, indocyanine green was administered via central venous access, and fluorescence laparoscopy confirmed adequate blood perfusion of the transplanted liver graft. The main surgical procedure is illustrated in Figure 2 (E and F). The operation duration

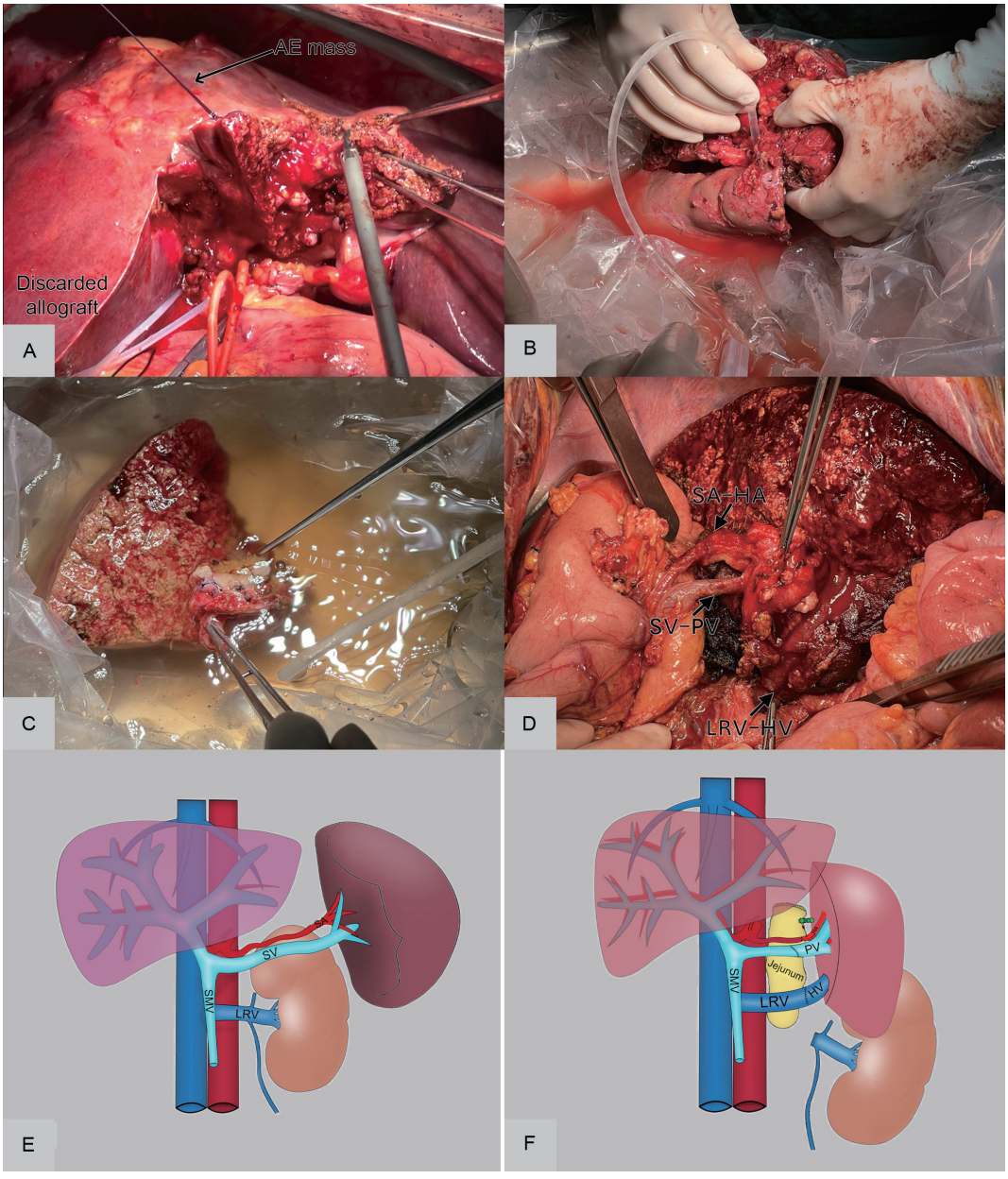

Fig. 2. The brief procedure for the surgery and schematic diagram. (A) AE mass and potential discarded allograft from the AE patient; (B) cold perfusion on the ice table for the right half liver; (C) AE mass resection, vascular reconstruction of the allograft *in vitro*; (D) heterotopic auxiliary LT of the discarded allograft from the AE patient; (E) the patient with PHT; (F) the discarded allograft was transplanted to splenic vessels after splenectomy to relieve PHT. SMV, superior mesenteric vein; PV, portal vein; LRV, left renal vein; HV, hepatic vein; HA, hepatic artery; BD, bile duct; SA, splenic artery; SV, splenic vein; AE, alveolar echinococcosis; LT, liver transplantation; PHT, portal hypertension.

was 8 h, with a cold ischemia time of 210 min. The patient did not develop any surgery- or anesthesia-related complications.

Postoperative course

The donor was managed according to the conventional protocol for partial hepatic resection. The recipient was administered tacrolimus and methylprednisolone on postoperative day 1 to prevent graft rejection. Daily ultrasonography was performed to evaluate the graft's vascular function. Additionally, albendazole was administered to both patients for AE prevention.

Both patients had an uneventful postoperative recovery. The hepatic AE patient received albendazole at 15 mg/kg/day for one year; during the 12-month postoperative follow-up period, there was no recurrence of AE. Daily ultrasonography of the recipient during the first postoperative week revealed no thrombosis in the PV, HA, and HV. Enhanced CT, blood biochemistry, and anti-*Echinococcus* IgG antibody testing were performed every three months after surgery to evaluate the vascular status, transplanted graft volume, liver function, and potential hydatid infection. To date, the recipient has been

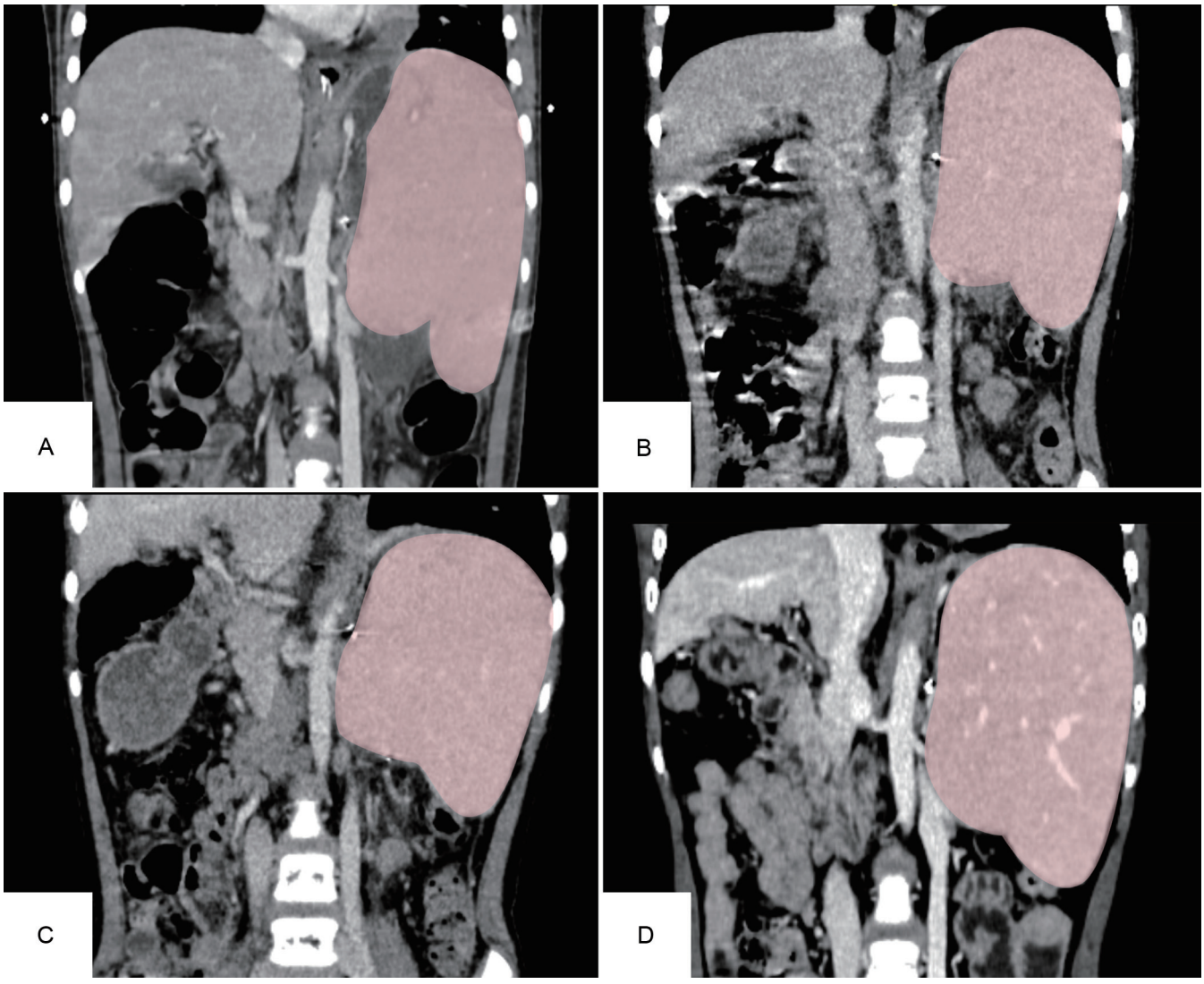

Fig. 3. The volumes of the girl's native and transplant liver. (A) One month post-operation, native liver: 434 mL, transplant liver: 232 mL; (B) Three months post-operation, native liver: 236 mL, transplant liver: 365 mL; (C) Five months post-operation, native liver: 205 mL, transplant liver: 397 mL; (D) 10 months post-operation, native liver: 174 mL, transplant liver: 443 mL.

followed for 12 months after surgery. During this period, the volume of the transplanted liver lobes increased from 232 mL to 443 mL, while the native liver volume decreased from 434 mL to 174 mL (Fig. 3, Supplementary Fig. 1). There was no evidence of stenosis or thrombus formation, and vascular patency has been well maintained. Blood biochemistry revealed stable hepatic function and coagulation profiles, with negative anti-*Echinococcus* IgG antibody results. Currently, the patient is receiving oral tacrolimus at 0.5 mg every 12 h.

This is the first report on heterotopic auxiliary LT using discarded hepatic segments from an AE patient with simultaneous replacement of the spleen, as well as on the use of discarded segments from the right hepatic lobe. Our experience with this case provides new insights into the management of pediatric patients with PHT.

Right hemi-hepatectomy was clearly the only radical cure for our hepatic AE patient. Specifically, segment 6 was severely affected by AE and could not be preserved *in vivo* during resection of the affected segments. However, based on our previous experience with *ex vivo* liver resection and autotransplantation, this segment could be repaired as a functional lobe *in vitro*.[12,13] Previous studies have shown that discarded liver segments obtained from patients with conditions such as cavernous hemangioma and/or FNH can be salvaged for use as functional grafts in LT.[5–7] Due to the benign nature of these conditions, in most cases of cavernous hemangioma and FNH, a "wait and watch" approach may be more reasonable than active surgical resection of functional hepatic parenchyma. Moreover, the benefit of such resection may be doubtful, as is the availability of a sufficient amount of usable discarded graft following resection.

In this paper, we examined for the first time the possibility of using a discarded graft obtained following resection of segments affected by AE. Our literature search (Supplementary Table 1) revealed no published reports on this topic, although there are four reports describing the use of discarded segments following resection for CE in LT. One of the most important considerations in this context is the risk of AE recurrence.

Among the reported CE cases, only one instance of recurrence occurred, in which partial pericystectomy rather than radical resection was performed. In our AE case, the allograft was obtained following radical resection of AE lesions. To minimize the risk of recurrence, the recipient was administered albendazole (10–15 mg/kg/day for one to two years).[13] Postoperative monitoring included enhanced CT/MRI scans at one month and every three months thereafter to assess graft volume and detect any AE recurrence, with quarterly anti-*Echinococcus* IgG antibody testing for long-term surveillance. During the 12-month postoperative follow-up period, no evidence of AE infection was noted on the CT images, and anti-*Echinococcus* IgG antibody tests remained negative. Further follow-up is necessary to monitor for potential recurrence. However, considering the patient's life-threatening condition at the time of LT and the fact that AE is less invasive than certain tumors, the risk of recurrence was deemed acceptable in this case.

Another important aspect of this case is that the discarded portion was obtained from the right half of the liver. In most previously reported cases of using otherwise discarded liver segments, grafts were obtained from segments 2 and 3; the anatomy of these segments makes it technically simpler to obtain grafts than from the right lobe.[6,7] Furthermore, *in vitro* repair of the left lobe is generally easier than that of the right lobe. However, these preconceptions may result in the exclusion of discarded segments from the right half of the liver that may have potential for use as allografts, as demonstrated in this case. Our success here is similar to our previous experience in obtaining allografts using discarded segments of the right hepatic lobe from patients with hepatolithiasis.[14]

Despite our successful experience in this case, further investigation is warranted to support our findings. As a single-center case study with short-term follow-up, no statistical inferences can be drawn at present. Future studies with larger sample sizes are needed to validate the generalizability of these findings.

In conclusion, we are able to identify a promising new source of grafts from discarded hepatic segments for LT. We believe it is important to share this preliminary experience with the scientific community, as the use of discarded hepatic tissue from AE patients may expand the donor pool in select pediatric cases with urgent needs and limited conventional options. To validate our findings, our approach should be tested at other transplant centers and their experiences reported. Further experience with this technique is recommended to encourage its wider adoption.

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Conflict of interest

The authors have no conflict of interests related to this publication.

Author contributions

Study concept and design (YZ, CY), acquisition of data (DC, XY), analysis and interpretation of data (CY, DC, XY), drafting of the manuscript (CY, DC, XY), critical revision of the manuscript for important intellectual content (YZ), administrative, technical, or material support (YZ, WC, TL WJ), and study supervision (BZ, JJ). All authors have made significant contributions to this study and have approved the final manuscript.

Ethical statement

The procurement of the graft from the discarded liver (living donor) was approved by the Medical Affairs Department and the Ethics Committee of the Sichuan Provincial People's Hospital (No. 202308), and informed consent was obtained from the patient for the publication of the article and accompanying images. Also, we state that none of the organs were procured from executed prisoners and that organs were procured after informed consent or authorization for this to advance to peer review.

Data sharing statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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