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Ex vivo Liver Resection and Autotransplantation as Alternative to Allotransplantation for End-stage Hepatic Alveolar Echinococcosis

Running Title:
Liver Autotransplantation in End-stage Hepatic Alveolar Echinococcosis

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All authors have declared that there is no conflict of interests regarding this study.

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Authors' contributions:

Authorship in this study has been strictly complied with international guidelines and contributions of all eligible authors listed below. Hao Wen, Jie-Fu Huang, Jia-Hong Dong and Ying-Mei Shao conceived the study and critically revised the manuscript. Tuerganaili Aji, Tuerhongjiang Tuxun drafted and edited the manuscript. Surgical procedures were performed by senior authors including Hao Wen, Jia-Hong Dong, Tuerganaili Aji and Ying-Mei Shao. The procedures were assisted by Jin-Ming Zhao, Tao Li, Paizula Salayiadiang, Bo Ran and Tie-Ming Jiang. Yi-Biao He conducted
preoperative liver volumetric analysis. Rui-Qing Zhang and Tuerhongjiang Tuxun collected clinical data.
Abstract

**Background & Aims:**

Radical resection is the best treatment for advanced hepatic alveolar echinococcosis (AE) patients. Liver transplantation is considered for selected advanced cases; however, shortage of organ donor and risk for post-operative recurrence remain challenging. The present prospective study assessed 69 end-stage patients treated by *ex vivo* liver resection and autotransplantation.

**Methods:**

In a prospective study, 69 consecutive end-stage hepatic AE patients were treated with *ex vivo* resection and liver autotransplantation between January 2010 and February 2017. The outcome in this technique was assessed for feasibility, safety and long-term clinical outcome.

**Results:**

*Ex vivo* extended hepatectomy with autotransplantation was successful in all patients without intra-operative mortality. The median weight of graft and AE lesion were 850 [370-1600] g and 1650 [375-5000] g respectively. The median duration of operation and anhepatic phase were 15.9 [8-24] hours and 360 [104-879] minutes respectively. Six patients did not need any blood transfusion. Complications higher than IIIa according to Clavien classification were observed in 10 patients. The 30-days mortality and overall mortality (>90 days) were 7.24% (5/69) and 11.5% (8/69) respectively. The mean hospital stay was 34.5 [12-128] days. Patients were followed-up systematically with a median of 22.5 months [14-89] without recurrence.

**Conclusion:**

This is the largest series assessing *ex vivo* liver resection and autotransplantation in end-stage hepatic alveolar echinococcosis. This technique could be an effective
alternative to liver transplantation in end-staged hepatic AE patients who needed neither organ donor nor immunosuppressive agents.

**Lay summary:**

Present large series of ELRA in end-staged hepatic AE patients describe a feasible surgical option with probably acceptable postoperative mortality, but 100% disease-free survival in survivors. Careful patient selection, precise assessment for size and quality of remnant liver are key to successful surgery.
INTRODUCTION:

Hepatic alveolar echinococcosis (AE) is a lethal infectious disease caused by the larval stage of *Echinococcus multilocularis* (*E. multilocularis*). This severe disease remains a major public health issue in pastoral area in China, Turkey, Central Asia, Mediterranean and some European countries\(^1\). AE is usually chronic and asymptomatic while primary hepatic involvement presents with a mortality rate of 75% to 90% after 10 to 15 years if untreated. So far surgery associated with albendazole medication has been considered a major radical procedure for clinically diagnosed AE patients. Of note, in late diagnosed cases, very few patients can benefit from surgery, due to extensive disease progression \(^2\). Retrospective studies have shown that palliative surgical procedures should be avoided in such cases, and the only feasible treatment is the long-term use of oral benzimidazoles \(^3\). Nevertheless, lifelong medications and their potential major side effects and the numerous complications of palliative resections with endless biliary drainage have motivated more radical approaches \(^4\). Given the devastating complications of AE and limited surgical option in advanced cases, transplantations emerged as curative and often palliative option. Although it was presented as legitimate approach, the need for organ donor was a limitation and life-long immuno-suppressants did increase recurrence risk. For these reasons, the decision to proceed to transplantation should be cautiously considered at best \(^5\).

In 1988, *ex vivo* liver resection followed by autotransplantation technique (ELRA) was firstly introduced by Pichlmayr as radical procedure for conventionally unresectable tumors in cases questionable for transplantation. This very advanced situation is in analogy commonly seen in patients with end-staged hepatic AE \(^6\). Dislike allotransplantation, ELRA requires neither organ donor nor
immunosuppressive agents. With the high incidence of advanced AE in Central Asia region, it was decided to use ELRA in non-operable cases with encouraging results in the first 15 cases \(^7\). The main advantage of ELRA was the possibility to treat very advanced in principle non-operable cases without any need for organ donor or post-operative immunosuppressive agent. As obviously, large scale studies are still missing, the aim of the present study was to report a large series on ELRA with 69 consecutive end-staged hepatic AE patients. The goal was to propose possible indications and selection criteria to discuss safety, feasibility and efficacy of this “orphan” and “promising” surgical technique.

**PATIENTS & METHODS:**

**Ethics**

Design of the study, management of the patients were in accordance with the Helsinki Declaration 1975 and approved by the Human Ethics Committee of first author’s institution. Written informed consents were obtained from all subjects and /or legal custodies.

**Patients:**

From January 2010 to February 2017, 300 hepatic AE patients underwent surgical resections at the first affiliated hospital of Xinjiang Medical University. Among them, 69 (23%, 69/300) needed ELRA, while others could be treated by conventional hepatic resection. Resectability and operability were carefully assessed by a multi-disciplinary team (MDT) including hepatobiliary surgeons, hepatologist, interventional therapist, radiologist, and anesthesiologists. Patient selection and treatment options as shown in Figure 1 were strictly followed. Unresectability for conventional hepatic surgery was defined as extensive hepatocaval involvement along with three hepatic veins, and retrohepatic *vena cava* (RHVC) involvement with or
without tertiary vascular branches involvement. In these advanced situations, a conventional resection would induce uncontrollable bleeding and irreversible ischemic injury due to the need of intensive vascular preparation and parenchymal resection.

Of note, during the study period only 3 patients received allotransplantation due to disseminated AE lesion with end-stage biliary cirrhosis in one case, a Budd-Chiari syndrome, and an insufficient residual liver volume. These 3 patients are excluded from the present study.

**Preoperative Assessment**

Preoperative thoraco-abdominal computed tomography (CT), liver magnetic resonance imaging (MRI) and all-body-positron-emission tomography (PET) were systematically used to assess lesion’s site and size, parenchymal, vascular and biliary extension and extra-hepatic metastasis. Preoperative volumetric calculation was achieved by using three-dimensional (3D) visualization imaging. Disease status of AE patients were categorized according to World Health Organization (WHO) PNM classification. Doppler ultrasound of jugular and greater saphenous veins was examined as potential vascular substitutes. Digital subtraction angiography (DSA) was considered to confirm the existence of tangible collateral circulation when total obliteration of RHVC was indicated by imaging studies. (Figure 2).

Unresectability for conventional hepatic surgery was considered when hepatocaval region along with three hepatic veins and retrohepatic *vena cava* (RHVC) were involved; tertiary branches of portal veins and arteries were invaded, and thus requiring a complex reconstruction with long ischemic time. Indication to ELRA was based on precise following anatomic and functional criteria: Extensive AE lesions with hepato-caval confluence involvement and three hepatic veins; Involvement up
to tertiary portal and arterial branches which need for critical reconstruction; Patients with graft volume $\geq 40\%$ Estimated Standard Liver volume (ESLV); Patients with total bilirubin level higher than twice the upper limit of normal value ($\leq 60 \mu\text{mol/L}$); Routine PTCD was performed in cases with obstructive jaundice. The contraindications to ELRA was: Hepatic congestion with Budd-Chiari syndrome; Patients with multi-organ AE, relative contraindication, if extra-hepatic lesions can be controlled by albendazole. Of note, such procedure is only possible with available expertise in liver transplantation for possible allo-transplantation rescue.

**Pre-operative interventional therapies**

Percutaneous transhepatic cholangial drainage (PTCD) or / and endoscopic retrograde cholangiopancreatography (ERCP) was performed when preoperative obstructive jaundice was manifested. The threshold level of total bilirubin (TB) for intervention was set as 60 umol/L. In subjects with future liver remnant (FLR) to standard liver volume (SLV) ratio (FLR/SLV) lower than 30%, selective portal vein embolization (PVE) was considered aiming to prevent postoperative hepatic failure.

**Albendazole**

Preoperatively some patients received Albendazole in their initial hospital prior to referral to our tertiary center (see table 2). All patients were put under albendazole postoperatively for 2 years as recommended.

**Types of graft**

Based on preoperative assessment for surgical planning, autograft was categorized regarding its anatomical site of liver lobe as Type I (left lateral), Type II (right posterior lobe), Type III (Right), Type IV (left medial), Type V (left lateral + right posterior).

**Surgery**
On-table resection

After accessing the abdomen, the presence of any extra hepatic lesions was carefully ruled out and the presence of intra hepatic micro lesion assessed by intraoperative ultrasound. Subsequently, dense adhesions caused by AE lesions were carefully released and hilar soft tissues and surrounding lymph nodes resected. Afterwards, en bloc resection of the entire liver together with RHVC was performed. If the diaphragm was also involved, local resection was performed. All specimens were sent to pathological examination.

Hemodynamic stability during anhepatic phase

After total liver and vena cava resection, two surgical teams started bench resection and intra-abdominal temporary vascular reconstruction respectively. For the anhepatic phase, when necessary (poor hemodynamic tolerance) a Gore-Tex prosthetic graft was interposed to reconstruct the vena cava with or without additional porto-systemic shunt. In selected cases, the graft then was left in place for the reconstruction. The detailed pattern approaches and possible indications are shown in Figure 3.

Ex vivo Resection

Hypothermic perfusion via intact portal vein was started immediately after liver resection. Organ preservation solution applied were University Wisconsin (UW) solution in the 38 first cases, histidine-tryptophan-ketoglutarate (HTK) solution in the further 31 cases. Extended hepatectomy was carried out based on the type of the possible future grafts. Both cavitron ultrasonic surgical aspirator (CUSA) and bipolar electric cautery were used for parenchymal dissection. RHVCs were peeled off as long as possible for further reconstruction. Safe margin was guaranteed with negative pathology confirmed by repeated frozen section. AE lesion and graft were weighed.
separately. Defects of RHVC, hepatic veins, and portal vein were patched or/and bridged using venous substitutes. Finally, any potential leaks were carefully detected via repeated organ perfusion and sutured before implantation.

**Autotransplantation**

Once the graft preparation was achieved, IVC prosthetics were removed and porto-systemic shunts discontinued for implantation process. The detailed reconstruction patterns of hepatic vein, portal vein, artery and biliary tracts are displayed in Table 1.

**Post-operative management and follow-up**

Postoperative complications were assessed based on the Clavien classification. During the early post-operative days, patients with prosthetic graft left in situ were given standard prophylactic anticoagulant and anti-aggregant agents. Subjects were submitted to standard postoperative albendazole treatment for two years as recommended in the literature. The liver function test, serological test, ultrasonography, CT, and PET scans were performed to assess size and quality of the graft, as well as possible recurrence, if any.

**Statistics**

Results were given as median value with range, and Student T-test was used when necessary, $p$ value <0.05 was considered significant.

**RESULTS**

*Ex vivo* extended hepatectomy with autotransplantation was performed successful in all 69 patients. The baseline characteristics of the cohort are displayed in Table 2.

The median weight of graft and AE lesion were 850 [370-1600] g and 1650 [375-5000] respectively. The graft mass and standard liver volume (GM/SLM) ratio ranged
from 37 to 125 % with a median of 72%. The median duration of operation and anhepatic phase were 15.9 [8-24] hours and 360 [104-879] minutes respectively. All but six patients needed blood transfusion. The median amount of blood loss and transfused RBC were 1000 [400-15000] ml and 5 [0-32.5] U respectively as shown in Table 3. Additional surgeries were performed when necessary to achieve radical resection and included phrenectomy (n=12), lung lobectomy (inferior right lobe) (n=5), nephrectomy (n=2) and others various resection as indicated (cardiac sac resection for example (see table 3). Lung resection was only performed when AE lesion was localized in lower lobe.

The intraoperative mortality was zero. The most frequent postoperative complication was pleural effusion in 18 patients (26%). Complication higher than Clavien IIIa were observed in 10 patients (14%). The 30-days mortality was 7.24 % (5/69) and further 3 patients deceased within 90 days, giving an overall mortality of 11.5% (8/69). The causes of mortality were liver failure in 5/8 patients, septic shock in 2/8 patients, and postoperative intra-abdominal bleeding in 1/8 patients (see table 4). Post-operative pathology showed no secondary biliary cirrhosis but fibrosis in all subjects. Patients who died postoperatively compare to survivors had no differences regarding GM/SLM ratio (76 % vs. 71%, p=0.48), but a trend for longer surgical (18 hours vs. 16 hours, p=0.127) and longer anhepatic duration (412 minutes vs. 368 minutes, p=0.37). Nevertheless, intraoperative blood loss (5050 ml vs. 1465 ml, p=0.0001) and blood transfusions (17 units vs. 6 units, p=0.0001) were higher in deceased patients.

The median follow-up in 60 surviving patients was 22.5 months [14-89]. The dead patients were excluded and one single patient was lost for follow-up. In 5 patients, *vena cava* did not need to be reconstructed because of rich collateral circulation. Of note, in these patients there was neither lower extremities edema nor
renal dysfunction observed.

The postoperative vascular patency (*vena cava* with hepatic veins, hepatic artery and, portal vein) was assessed systematically and confirm by CT scan in all patients. The 5-year (n=3), 4-year (n=10), 3-year (n=14), 2-year (20/20), and 1-year (n=31) disease free survival (DFS) were 100%.

As comparison, and despite of different indications and surgery, the outcome of the 228 hepatic AE patients treated during the study period by conventional liver resection are following: 90-day mortality 3%, recurrence rate 2%.

**Discussion:**

To the best of our knowledge, the present study analyses the largest series of *ex vivo* liver resection with auto-transplantation in end-stage hepatic alveolar echinococcosis. The revival of this challenging technique initially used in oncologic liver surgery may represent an interesting alternative to transplantation or palliative albendazole in AE. However, careful patient selection, precise indications and adequate assessment for size and quality of future remnant liver are key to successful management.

Hepatic AE is a neglected but still lethal disease especially in developing countries and should be managed in specialized centers. Surgery associate with albendazole is the best curative option especially in advanced cases. Nevertheless, about 25% of AE patients treated in our center had to be considered as beyond resection possibility. In rural and pastoral regions like Central Asia, patients are diagnosed rather late (patient delay, doctor delay, large distances to specialized centers etc.), which explain the large number of advanced cases in the present study. Up to date, for these advanced cases, either albendazole (with or without palliative surgery), or allotransplantation might be considered. In fact, although, the long-term
albendazole administration sound to be safer, clinical outcome is poor with 5-year survival between 10% and 40%. In patients with nonresectable AE, long-term administration of albendazole can reduce the mortality to <20%, however, this is costly and could have side effects in 5-10% patients and it is potentially teratogenic and oral contraception is required for women of child-bearing age. In our previous cohort with 12 end-staged patients who received albendazole treatment alone, only five patients were stable with the treatment, and five needed liver resection, one liver transplantation and the other one PTCD due to biliary complication.

Until recently, allotransplantation was considered as last resource in AE and the reported 5-year survival was up to 70%. Nevertheless, transplantation in AE is controversial due to transplantation inherent limitations (organ shortage, absence of adequate MELD score in AE patients) and relatively high post-operative recurrence due to immunosuppressive treatment. Thus, indication to allotransplantation in AE has decreased dramatically over the last few years, as confirmed by the fact that 3 patients only needed allotransplantation in our series and are excluded from the present analysis.

The surgical treatment for end-stage hepatic AE reported in the present study was ELRA, with the benefit of requiring neither organ donor nor post-operative immunosuppressive agents, the main cause of disease recurrence. In this series, the post-operative mortality was comparable to allotransplantation, but the clinical outcome was better. Although their data were heterochronic, Koch et.al reported Five-year survival of 71%, with a 5-year disease-free survival of 58%. The early deaths reported were mostly related to bacterial or fungal infections, in patients in poor condition at the time liver transplantation was performed. In comparison to this historical large cohort on transplantation, the results of the present study on ELRA
displayed lower post-operative mortality and better survival despite shorter follow-up.

During a 10-year experience in our center with more than 500 hepatic AE cases, it could be observed that parasitic lesion presented a unique “retrograde” growth pattern with mainly hepatocaval invasion and secondary or/and tertiary vasculatures (including biliary tree), growing through the portal vein branches. As AE growth slowly, ipsilateral portal flow decrease, inducing compensatory portal inflow in the normal liver tissue. The chronic hypoperfusion of the involved liver side induce an hypertrophy of contralateral hepatic parenchyma similar to hypertrophy observed after portal vein embolization⁷, ¹⁹. This was confirmed in the present study by a median GM/SLM ratio of 72%, significantly higher than the classical 30% threshold. For this reason, autografts in the present study were categorized regarding their anatomical segments from Type I to V. In the present series, 54 cases were Type I (left lateral). This might be explained by the high angle between portal trunk and sagittal section of left portal vein that may bar the parasite from left lateral lobe.

The management of preoperative biliary obstruction and intraoperative vascular reconstruction are two strategical major challenges. In the current study, 15 out of 69 cases presented with obstructive jaundice required biliary drainage prior to ELRA. Post-operative pathology showed no secondary biliary cirrhosis but fibrosis in all patients. Individual management of anhepatic phase as well as vascular reconstruction were challenging. In the historical ELRA, veno-venous bypass (VVB) was used routinely to control hemodynamic stability during anhepatic phase⁶, ²⁰, ²¹. However, complications such as pulmonary thromboembolism or post-reperfusion syndrome were reportedly in up to 30% of cases ²². In 2006, the first patient with ELRA performed for cholangiocarcinoma in China developed mental disorder after VVB ²³. This clinical case and further experimental study showed that temporary *vena cava*
reconstruction and additional porto-systemic shunt were safer and more effective to maintain hemodynamic stability during long anhepatic phase\textsuperscript{7,24}. With respect to the slow growth of AE lesion with chronic compression or even obliteration of the \textit{vena cava}, extensively rich collateral vascularization developed\textsuperscript{25}.

Post-operative hepatic failure remains the main and life-threatening complication after ELRA\textsuperscript{26,27}. In the present series, the mortality due to liver failure may be explained by prolonged ischemic time due to complex vascular reconstruction and massive intraoperative bleeding due to extensive adhesions are the main reasons. This make the patient selection and precise indication key element of end-stage AE management. All patients in the present study who died of liver failure were Child B. However, 10 patients with Child B survived. So unfortunately, despite caution in those patients, with adequate measured FRL and pre-operative jaundice reduction, this study cannot display clear exclusion criteria provided the patients meet the surgical indication criteria displayed in figure 1. For this reason, end-stage AE patients with compromised hepatic quality due to chronic obstruction of hepatic vein without compensatory collateral circulations should be cautiously considered prior to surgery.

This study has some limitations that need to be addressed. First, this study reports the experience of a highly specialized AE center in central Asia, with a selection of patients from rural and pastoral era, thus explaining the high number of very advanced late diagnosed cases. Then the ELRA was initially developed for advanced cancer, but as AE behave locally like invasive cancer, the use of ELRA represent a logical extension of indication to AE. In these advanced cases with reduced liver function, Albendazole alone may not be a valuable option. Finally, the long-term postoperative mortality with liver failure may be regarded as high compared to current mortality after liver resection or liver transplantation. However,
the AE end-stage disease has such a poor prognosis without treatment that the risk taken, provided they are exposed honestly to the patients, are worth it, with 100% disease-free survival in survivors.

In conclusion, the present large series of ELRA in end-staged hepatic AE patients describe a feasible surgical option with probably acceptable postoperative mortality of 12%, but 100% disease-free survival in survivors. Careful patient selection, precise assessment for size and quality of remnant liver are key to successful surgery. Further cohorts with high number of patients with longer follow-up may confirm, or not, the results of the present study.

References:


**Figure 1.** Algorithm of surgical treatment in patients with end-staged hepatic alveolar echinococcosis

Note: HAE, hepatic alveolar echinococcosis; HV, hepatic vein; L, length; C, circumference; TBL, total bilirubin; PTCD, percutaneous transhepatic cholangial drainage; FLR, future liver remnant; ESLV, standard liver volume; DCD, donor after cardiac death; LDLT, living donor liver transplantation; PVE, portal vein embolization.
Figure 2. Pre-operative assessment and surgical techniques.

A. Preoperative MRI scan show a massive AE lesion occupying the entire right lobe and left medial lobe. B. Corona section of CT scan showed same AE lesion. C. A 3D reconstruction of the patient’s AE lesion and its involvement to vessels. D. Preoperative DSA showed the complete obliteration of RHVC with rich collateral circulation. E. En bloc resection of the whole liver with the RHVC was carried out. F. Regarding the stable hemodynamics, rich collateral circulation and without intestinal congestion, neither porto-systemic shunt nor caval reconstruction was performed. G. Explanted whole liver. H. The AE-free left lateral lobe was re-implanted. I. Reconstruction of hepatic vasculatures.
**Figure 3.** Hemodynamic stability pattern during the anhepatic phase.

Porto-systemic shunting and/or caval reconstruction was performed during anhepatic phase. The confirmation of presence and accuracy of “rich collateral circulation” was based on following characteristics: Slow growth nature of the lesion which may display a chronic process of invasion that allows body to establish collateral circulation; The ordinary pre-operative CT angiography, three dimensional reconstruction, and invasively, digital subtraction angiography (DSA) based phlebography provided a visual assessment for well-established collateral circulation; Patients with no signs and symptoms of venous reflux obstruction when the complete obstruction of retrohepatic *vena cava* was evidenced by imaging studies; An on-table observation of hemodynamic stability and gastrointestinal venous congestion was final step for confirming the “rich collateral circulation”. With the above steps, no subject was initially stable and then deteriorated during the anhepatic phase.

**A:** The giant AE lesion occupied whole liver except left lateral lobe with retro-hepatic vena cava involvement; **B.** The whole liver was explanted; **C:** For those with unstable hemodynamic situation, poor intestine condition and inadequate collateral circulation, both of caval reconstruction and porto-systemic shunt was required; **D:** For those with stable hemodynamic situation, good intestine condition but with inadequate collateral circulation, caval reconstruction alone was performed; **E:** For those with poor intestinal condition but with adequate collateral circulation, porto-systemic shunt alone was mandate; **F:** For patient with stable hemodynamics, rich collateral circulation and without intestinal congestion, neither porto-systemic shunt nor caval reconstruction was performed.
Table 1. Detailed surgical aspects and reconstruction patterns

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Note: Based on preoperative assessment for surgical planning, autograft was categorized regarding its anatomical site of liver lobe as Type I (left lateral), Type II (right posterior lobe), Type III (Right), Type IV (left medial), Type V (left lateral + right posterior). RHVC: retro-hepatic vena cava; H1: hepatic vein to RHVC (end to end); H2: hepatic vein to the
stump of supra-hepatic vena cava (end to end); H3: hepatic vein to prosthetic graft (end to side); P1: graft portal vein to portal trunk (end to end); P2: sagittal portion of left portal vein to portal trunk (end to end); P3: vein graft interposition; B1: graft biliary duct to common bile duct; B2: sagittal portion of left hepatic duct to common bile duct; B3: Choledechojejunostomy; A1: graft hepatic artery to proper hepatic artery; A2: left medial hepatic artery to aberrant right hepatic artery.
Table 2. Baseline information of 69 patients with end-staged hepatic alveolar echinococcosis

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**Albendazole administration**

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**Diagnosis to surgery**


**Child-Pugh classification (# of Pts)**

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**PNM classification**

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Note: Based on preoperative assessment for surgical planning, autograft was categorized regarding its anatomical site of liver lobe as Type I (left lateral), Type II (right posterior lobe), Type III (Right), Type IV (left medial), Type V (left lateral + right posterior). PTCD: percutaneous transhepatic cholangial drainage; ERCP: endoscopic retrograde cholangiopancreatography; PVE: portal vein embolization.
### Table 3. Detailed surgical aspects and peri-operative parameters

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**Concurrent surgery**

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**Complications**

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**Clavien-Dindo Classification**

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**Hospital stay**

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**Follow-up**

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Note: Based on preoperative assessment for surgical planning, autograft was categorized regarding its anatomical site of liver lobe as Type I (left lateral), Type II (right posterior lobe), Type III (Right), Type IV (left medial), Type V (left lateral + right posterior). GM: graft mass; SLM: standard volume mass; UW: University of Wisconsin; HTK: histidine-tryptophan ketoglutarate; RBC: red blood cell.
Table 4. Detailed information with postoperative death

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</tbody>
</table>
Note: Based on preoperative assessment for surgical planning, autograft was categorized regarding its anatomical site of liver lobe as Type I (left lateral), Type II (right posterior lobe), Type III (Right), Type IV (left medial), Type V (left lateral + right posterior). GM: graft mass; SLM: standard volume mass; UW: University of Wisconsin; HTK: histidine-tryptophan ketoglutarate; IVC: inferior vena cava; MODS: multiple organ dysfunction syndrome.
Graphical abstract
Highlights

- Radical resection associated with albendazole treatment is the best treatment for advanced hepatic alveolar echinococcosis (AE) patients;
- Liver transplantation is considered for selected advanced cases; however, shortage of organ donor and risk for post-operative recurrence remain challenging;
- Present large series of ELRA in end-staged hepatic AE patients describe a feasible surgical option with probably acceptable postoperative mortality, but 100% disease-free survival in survivors.