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Case Series

Technical characteristics and quality of grafts in liver procurement from brain-dead donors: A single-center study in Vietnamese population

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ABSTRACT

Introduction: Donor liver graft quality plays an especially important role that contributes to the success of organ transplantation. Almost all local and international authors are interested in the techniques and results of transplantation, however, in Vietnam, there have not been any studies that report the results of liver procurement from brain-dead donors from a technical perspective as well as the morphology and function of the transplanted organ.

Materials and method: This study is descriptive cross-section study with analysis of retrospective occurrences of a series of cases of liver procurement from brain-dead donors from March 2010 to March 2020. All cases were proceeded the multiple organ procurement with warm liver dissection and in vivo cannulation and perfusion.

Results: The average age of brain-dead donors was 29.7 ± 10.7 (18–69), 92.16% of the harvested organs were of good quality macroscopically; and the rate of anatomical modification was 33.3% that occurred mostly in the left hepatic artery (LHA). Technically, warm dissection was proceeded in majority of cases (98,0%), the graft implantation was performed by this technique with mean cold ischemia time (CIT) of 190,0 ± 100,5 min and WIT of 74,0 ± 39,2 s. There were no complications relating to graft injuries occurring during procurement and no primary liver failure, good results accounted for 94.1% of the total number of transplants postoperatively.

Conclusion: Multiple organ procurement with warm liver dissection and in vivo cannulation and perfusion was a safe technique and may be effective by avoiding any donor's damages in cold-phase dissection.

1. Introduction

The Vietnamese history of organ transplantation started in 1967 with an experimental liver transplantation on dogs performed by Professor TON That Tung [1]. Several decades later, the first successful human liver transplant in Vietnam was performed on January 31, 2004. In 2006, the first experimental liver transplantation from a brain-dead donor was performed within the framework of a national study conducted by Professor PHAM Gia Khanh et al. On May 22nd, 2010, NGUYEN Tien Quyet and his team successfully conducted the first liver transplantation from a brain-dead donor. In many ways, this was a remarkable milestone for the development of multi-organ transplantation from brain-dead donors from diagnosis and intensive care of brain-dead donors to surgery and the coordination of organizing an organ transplantation and contributes to encourage organ donations from those donors [3,5,6].

Abbreviations: BMI, Body mass index; CD, Cold dissection; CIT, Cold ischemia time; BDD, Brain-dead donors; IVC, Inferior vena cava; GDA, Gastroduodenal artery; HA, Hepatic artery; HV, Hepatic vein; MOP, Multiple organ procurement; MPV, Main portal vein; LT, Liver transplantation; OLT, Orthotopic liver transplantation; PGD, Primary graft dysfunction; SA, Splenic artery; WD, Warm dissection; WIT, Warm ischemia time.

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The quality of the graft is a very important contribution to a successful organ transplantation. Regarding multi-organ procurement techniques, authors of the French medico-surgical encyclopedia (EMC) used the term "la nerf de la guerre," which means the driving force to impress the important role of procurement stage. A good organ graft needs to be both anatomically and functionally tested and guaranteed. Therefore, multi-organ procurement from a brain-dead donor is a complicated operation requiring multiple teams that needs to be quickly completed. Any technical error in procurement or improper preservation might lead to irreversible injuries or life-threatening complication for the recipient [8,9]. Almost all domestic and foreign authors are keenly interested in the technique and results of the recipients. In 2012, NGUYEN Quang Nghia et al. [10] summarized adult liver transplantation at Vietnamese single-centre from 2007 to 2012 and described the protocol of liver procurement from brain-dead donors. After that, DANG Kim Khue and NGUYEN Quang Nghia summarized adult liver transplantations, which were mostly orthotopic liver transplantation from brain-dead donors. In any case, the authors mainly mention the transplantation technique and related factors of liver recipients [11,12].

Meanwhile, characteristics of donors as well as protocols of organ procurement and preservation–factors that directly relate to the quality of transplanted organ–have not received much attention, especially in Vietnam. There has not yet been any research in Vietnam that evaluates the results of liver procurement from technical aspects as well as the morphology and function of the transplanted organ. So, this study was conducted with aims to describe the technical characteristics of liver procurement and evaluate the morphological and functional quality of the grafts.

2. Material and methods

2.1. Study population

Approval was obtained from the Institutional Review Board (IRB). 'This case series has been reported in line with the PROCESS Guideline' at the end of the methods section (and include citation in the references section) [13] and was registered in accordance with the declaration of Helsinki (ID: researchregistry6795, https://www.researchregistry.com/register-now#home/registrationdetails/6093aab48b06c6001b8ef16d). Data was retrospectively collected from a prospectively maintained LT database and the medical records of all BDD over 18 years-in-old from March 01, 2010 through March 31, 2020 were reviewed. Patients that remained on the transplant waitlist as of March 31, 2020 were excluded from this study. Cut off of March 31, 2020 was used to have a meaningful follow-up period. From the clinical database, 51 patients who underwent multiple organ procurement from March 01, 2010 through March 31, 2020 were recruited in the study.

2.2. Selection criteria

- Donor: over 18 years old, severe cerebral injuries (head trauma, cerebral vascular accident, ruptured cerebral vascular aneurysm …) and was diagnosed brain dead according to Vietnam Ministry of Health's regulations; Liver was qualified and transplanted to corresponding recipient with complete medical record.
- Recipient: Liver cirrhosis: MELD score over 15 points or Child-Pugh score over 7 points, decompensated cirrhosis, HCC without extrahepatic metastasis, portal vein invasion or acute liver failure: due to medication, virus or mushroom poisoning without severe underlying diseases that might affect the prognosis.

2.3. Data collection

Data collected included patient demographics, clinical data of donors (general information, reasons of brain death, etc.) and recipients; the characteristics of graft procurement technique and preservation procedure (warm dissection time, perfusion fluid, cold and warm ischemia time, etc.); evaluating quality of graft ((liver grafts morphology, hepatic artery's aberrant anatomy, graft's biopsy, etc.) and surgical outcomes (complications according to Dindo-Clavien classification of surgical complications, hepatic function, overall short-term outcome).

2.4. Definitions

- Warm dissection: This technique refers to identification and control of all the elements of the hepatic hilum before cannulation and perfusion.
- Cold dissection: or rapid organ procurement, is a terminology that refers to identification and control of all the elements of the hepatic hilum in back-table, after cannulation and perfusion.
- Cold ischemia time (CIT): is defined as the interval from initiation of donor in vivo cold organ preservation to removal of the graft from 4 °C cold storage.
- Warm ischemia time (WIT): is defined as the interval from withdrawal of life support (in our study, it is time with clamping the supraceliac aorta) to initiation of cold organ preservation.

2.5. Statistical methods

Continuous variables are presented as a mean with standard deviation, or as median with range or interquartile range, depending on the distribution of the data. All statistical analyses were performed using SPSS, version 22.0 for Windows statistical software.

2.6. Surgical protocol (with Video S1)

- **Step 1: Abdominal opening, exploration, evaluation**

Complete abdominal exploration: tumor, organ traumatic injury. Evaluation of liver quality. Biopsy of 1 piece at segment 2 or 3 to assess the cirrhotic level, steatosis. Exploration of hepatic pedicle.

- **Step 2: Vascular preparation**

Cattel Brash procedure. Explore abdominal aorta, inferior vena cava. Avoid injury of lumbar arteries. Explore infra-diaphragmatic abdominal aorta. Open along the posterior peritoneum. Partially resect left diaphragmatic pillar until exploration of the anterior face of abdominal aorta.

- **Step 3: Exploration of hepatic pedicle components and important anatomical remarks, liberation of the liver and splenopancreatic bloc.**

Dissect the hepatic pedicle following the principle of exploring all hepatic pedicle components while assuring absolute security. Perform surgery in the following order: cholecystectomy; ligate right gastric artery; open hepatic pedicle peritoneum; lymphadenectomy of group 8, 12 and 13; explore the common hepatic artery; explore the gastro-duodenal artery (GDA); explore the common bile duct and portal vein right above the superior border of pancreas; liberate the liver. In our technique, we explore and isolate all hepatic pedicle components in the intending position of dissection with purpose is not harmful to any components, especially the hepatic artery with anatomical variations such as then proper hepatic artery (PHA) divided earlier than usual, or right hepatic artery (RHA) originate in the GDA.

- **Step 4: Thoracic opening and cardiac and lungs' vascular preparation if cardio-pulmonary procurement is planned.**
- **Step 5: Vascular cannulation, flush perfusion.**

This step is the most important as it requires the synchronized cooperation between surgeons and surgical instrument technicians to make the warm ischemia time as short as possible because of aortic clamping until the complete cold preservation of the liver.

- **Step 6: Organ procurement: heart, lungs, liver, spleen, pancreas, abdominal aorta, and inferior vena cava.**

After perfusion, the organs must be retrieved as quickly as possible to minimize cold ischemia time. The order of organ retrieval begins with the heart, the second are the two lungs, and followed by the abdominal organs.

Hepatic dissection starts with opening of the diaphragm, resection of the inferior vena cava (IVC) and surrounding diaphragm tissue, as well as the infrahepatic IVC superior to the renal veins. The hepatoduodenal ligament and the gastro-duodenal ligament are resected as close to the gastric lesser curvature as possible to minimize the risk of damaging THE accessory LHA from the LGA. Resection of GDA occurred with at least 5 mm remaining for reshaping if the accessory RHA is from the SMA. The common bile duct is resected in right above the duodenum in this step or in step 3. The main portal vein (MPV) is dissected at the portovenous confluence. In case the recipient had PV thrombus, the MPV should be preserved as long as possible. Finally, isolation and dissection of the celiac axis occurs with or without a path of aorta.

- **Step 7: Dissection on back-table.**

After placing all the harvested organs into a cooled preservation solution, the organs are immediately dissected on the back-table because most components were dissected on the operating table. Meanwhile, the results of organ procurement were evaluated on the wholeness of liver anatomy and the resection remarks of each component.

Video S1: Main steps of multiple organs procurement with in vivo perfusion and warm dissection.

Supplementary data related to this article can be found at https://doi.org/10.1016/j.amsu.2021.102654.

3. Results

From the clinical database, 51 patients who underwent multiple organ procurement from March 01, 2010 through March 31, 2020 were recruited in the study.

3.1. Overview

The common characteristics of organ donors were shown in Table 1. The average age of donors was 29.7 ± 10.7 and the working age (18–39 years old) was the majority. The male-to-female sex ratio was 6.3:1, the average BMI was 21.11 ± 2.24, and the most frequent brain-death cause was head trauma (90.2%). The recipient characteristics are shown in Table 2. The mean age of recipients was 51,6 ± 11,8 years; The predominant gender was male with the male: female ratio = 12: 1. The mean body mass index was 23,03 ± 3,10 kg/m2. Hepatocellular carcinoma was the most common etiology (n = 29). The model for end-stage liver disease (MELD) scores of recipients were 16,01 ± 10,31 with predominant group was mild group (60%).

Table 1
Common characteristics of organ donors.

Age groups and Mean age			Quantity (N)	Percentage (%)
Age group	18–39		42	82.4
	40–59		8	15.7
	≥60*		1	1.9
Sex	Male		44	86
	Female		7	14
Cause of brain death	Stroke		1	2.0
	Ruptured aneurysm		4	7.8
	Traumatic brain injury	Underwent surgery	11	21,6
		Not operated	35	68,6
BMI	21.11 ± 2.24 (17.58–27.80)			

Table 2
Recipient characteristics.

		Quantity (N)	Percentage (%)
Age (years)		51,6 ± 11,8 (9–77)	
Sex (Male/Female)		48/4	
Child-Pugh class	A	13	25,49
	B	23	45,10
	C	15	29,41
MELD class	6–14	30	60
	15–23	8	16
	24–29	3	6
	≥30	9	18
MELD	16,01 ± 10,31 (6–40)		
Cause of transplantation	Hepatocellular carcinoma	29	55.77
	Cirrhosis	17	32.69
	Acute liver failure	5	9.62
	Biliary atresia	1	1.92
	Biliary tree cancer	0	0
	Other	0	0
BMI	23,03 ± 3,10 (13.89–29.75)		

3.2. Technical characteristics and quality of grafts

The technical characteristics of multiple organ procurement were shown in Table 3. Warm dissection was proceeded in majority of cases (98.0%), in the remaining three cases, we used rapid technique for procurement for grafts transporting (2 cases) and unstable hemodynamic (1 case). In all cases, the fluid for perfusion is Custidiol. The graft implantation was performed by this technique with mean cold ischemia time (CIT) of 190,0 ± 100,5 min and WIT of 74,0 ± 39,2 s. The in vivo perfusion time and the quantity of fluid perfusion were 18,2 ± 6,0 min and 8,1 ± 1,9 l. The Back-table time and the temperature of fluid were 53,9 ± 23,8 min and 3,3 ± 0,6-degree C.

The morphological characteristics of liver grafts were shown in Tables 4–7. In almost all cases, liver had a good colour, soft density, and an edged border. There was one case of liver traumatic injury but only with a contusion of the Glisson's capsule. There were 2 cases where anatomical modifications were detected on the back-table. None were detected before surgery. Only 3 cases required angioplasty and all of them were of type 3. There was one case of congestion in the anterior segment of the right lobe because the liver was pressed under ribs. The majority (96.08%) of livers were complete except for only two cases of Glisson's capsule rupture during procurement. The average graft weight was 1286.9 ± 249.2 g, the ratio of graft-to-body weight was 0.023 ±

Table 3
Technical characteristics.

Technical characteristics		Quantity (N)	Percentage (%)
Warm dissection		48	94,1
Warm dissection's time (minutes, mean ± SD, min-max)		32,3 ± 10,3 (19–65)	
Fluid	Custodiol	51	100
	Other	0	0
Warm ischemia time (seconds, mean ± SD, min-max)		74,0 ± 39,2 (30–180)	
Cold ischemia time (minutes, mean ± SD, min-max)		190,0 ± 100,5 (65–648)	
Perfusion time (minutes, mean ± SD, min-max)		18,2 ± 6,0 (10–35)	
Quantity of fluid (liters, min-max)		8,1 ± 1,9 (3–15)	
Temperature of fluid (C-degree, mean ± SD, min-max)		3,3 ± 0,6 (2–4)	
Back-table time (minutes, mean ± SD, min-max)		53,9 ± 23,8 (29–155)	

Table 4
Gross appearance in the organ harvest stage.

Characteristics		n	Percentage (%)
Liver color	Normal	43	84.31
	Pale	4	7.84
	Yellowish	2	3.92
	Patchy	2	3.92
Liver density	Solid	15	29.4
	Soft	36	70.6
Liver edge (left lobe)	Blunt	6	11.76
	Edged	45	88.24
Liver trauma	Yes	1	3.9
	No	50	96.1
Anatomical variation of hepatic artery	Yes	17	33.33
	No	34	66.67
Liver quality	Normal	45	88.24
	Patchy necrosis	2	3.92
	Steatosis	4	7.84

Table 5
Hepatic artery anatomical variations.

Morphology	N	Percentage (%)	Description
Type 1	34	66.7	Common hepatic artery (CHA) originated from celiac trunk (CT), divided as proper hepatic artery (PHA) and gastro-duodenal artery (GDA) then PHA divided as left hepatic artery (LHA) and right hepatic artery (RHA).
Type 2	8	15.7	(1) => (6) LHA originated from left gastric artery (LGA) (7) (8) Accessory LHA originated from LGA
Type 3	3	5.9	(1) RHA originated from superior mesenteric artery (SMA) and ran behind the common bile duct (CBD) (2) Accessory RHA originated from SMA, CT and SMA had the same origin. (3) Accessory RHA originated from SMA
Type 5	1	1.9	CHA originated from SMA and ran behind the portal vein (PV)
Other	5	9.8	

Table 6
Assessment of anatomical condition of liver graft after harvesting and flushing.

Anatomical condition	Degree	n	%
Color after flush	Washy (good)	50	98.04
	Congestion	1	1.96
Liver	Complete	49	96.08
Vena cava	Complete	50	98.04
Arterial system	Complete	51	100
Portal vein system	Complete	51	100
Bile duct	Complete	51	100

0.0052 (kg/kg). There was only one case of split liver transplantation, of which 2 grafts weighed 890 and 410 g. There was one case of graft volume reduction because of an oversized liver.

3.3. The short-term outcomes

The short-term results after multiple organ procurement and liver transplantation were shown in Tables 8–10 and chart 1. Among 15 cases of postoperative complication, vascular complication accounted for 5 cases, transplant rejection was found in 2 cases, and there were 2 cases of haemorrhage due to coagulopathy. Both indicators of AST and ALT decreased after surgery, however, AST seemed to decrease significantly faster. There were no cases of post-transplantation primary hepatic function disorder. A majority (98%) had good post-transplantation liver function after 7 days. Complications of grade I made up the majority

Table 7
Morphological characteristics of liver graft.

Characteristics		Whole liver transplant	Split liver transplant	
			Right lobe graft	Left lobe graft
Graft weight /body weight (kg/kg)		0.023 ± 0.0052 (0.0156–0.0382)	0.0178	0.0082
Hepatic artery	Length (cm)	6.31 ± 0.87 (5–8.5)		
	Diameter (cm)	0.59 ± 0.07 (0.4–0.7)		
Splenic artery	Length (cm)	1.12 ± 0.59 (0.5–3.1)		
	Diameter (cm)	0.61 ± 0.12 (0.4–0.8)		
Gastroduodenal artery	Length (cm)	1.13 ± 0.40 (0.5–2.2)		
	Diameter (cm)	0.35 ± 0.11 (0.2–0.5)		
Portal vein	Length (cm)	4.64 ± 0.80 (3–6)		
	Diameter (cm)	1.88 ± 0.30 (1.2–2.4)		
Bile duct	Length (cm)	3.54 ± 0.78 (2.5–6)		
	Diameter (cm)	0.74 ± 0.15 (0.5–1.2)		
Inferior vena cava	Length (cm)	4.04 ± 0.50 (3–5.2)		
	Diameter (cm)	1.90 ± 0.60 (0.5–3)		

Table 8
Post-transplantation complications.

Post-transplantation complications	N	Percentage (%)	Description
Complication(s) of hepatic artery	1	1.92	Hepatic artery stenosis
Complication(s) of PV	3	5.77	Portal vein stenosis
Complication(s) of hepatic vein (HV)	0	0	
Complication(s) of biliary tract	1	1.92	Post-transplant cholestasis
Transplant rejection	2	3.85	(1) Multiple organ failure (2) Grade II graft rejection by William classification
Postoperative haemorrhage	3	5.77	2 cases due to coagulopathy 1 case with haemorrhage from lateral branch of hepatic artery near anastomose
Others	5	9.62	(1) Liver tissue damage (2) Bloodstream infection (3) Pleural hematoma (4) Sternal wound infection (5) Partial thrombosis of inferior vena cava
Total	15/52	28.85	

Table 9
Hepatic function grading at 7 days post-operation. (PGDF: Primary graft disfunction, PGNF: Primary graft nonfunction)

Results	n	%
Good: AST < 1000U/L, PT > 50%.	51	98,08
PGDF: one of three criterias: (1) AST or ALT > 2000 U/l at 7th day post-op (2) INR ≥ 1.6 at 7th day post-op or (3) Billirubin ≥ 10 mg.dl (171 umol/l) at 7th day post-op	1	1.92
PGNF: PDGF with liver transplantation after 7 days	0	0

Table 10
Grading of complications according to Dindo-Clavien classification of surgical complications and assessment on discharge.

TT	Index		n	%
1	Grading of complication	Grade 1	13	25.0
		Grade 2	6	11.5
		Grade 3	30	57.6
		Grade 4 and 5	3	5.8
		Total	52	100
2	Assessment on discharge	Good	49	94.2
		Bad	3	5.8

with 71.1%, while grades 2, 3, and 5 accounted for 15.4%, 7.7%, and 5.8% (3 cases), respectively. "Not good" outcomes on discharge occurred in 3 cases of death or hospice, which accounted for 5.8%. On the other hand, 49 cases were discharged, and the patients returned to normal life as before transplantation, which accounted for 94.2% of the total.

4. Discussion

The average age of our study group was lower than those of other authors around the world [14,15]. The majority selection of young people, mostly below the age of 40, was because liver transplantation was newly developed in Vietnam barely 10 years ago, so, certain results from quality grafts were essential. Quirino Lai et al. [16] conducted a study on the differences of the liver in various age groups of 188 cases and realized that liver grafts from over-70-year-old donors were worse than those of younger groups. The male donor accounted for more than 86% in our study. This ratio might be explained as head trauma was also mostly seen in male.

In our study, there were 3 types of liver transplantation. Among them, most cases (94.23%) were orthotopic liver transplantation while there was one reduced size liver transplantation (left lobectomy) and one split liver transplantation. Our study has a lower split liver transplantation rate in comparison with Harald Schrem et al.'s study [17] in 770 cases of liver transplantation with 68 cases of split liver transplant (8.83%). This could be explained by the difficulty of this technique and the strict criteria of donor and recipient selection; therefore, it was not widely applied. Screening for anatomical variations of hepatic arteries was very important in order to avoid any arterial injury during organ procurement. In our group, there were 17/51 (33.3%) cases of anatomical variations including 15 cases of per-operative detection.

In technical aspects, we used warm dissection associated with in vivo cannulation and perfusion in majority of cases (98.0%). In the remaining case, we used rapid technique for procurement for grafts transporting. In 48 cases applied this technique, there were two cases which had some struggles with bleeding from the gastroduodenal artery (GDA) and the right gastric vein (RGV) in junction with portal vein (PV), but there were no damages of hilar components finally. The mean time of warm dissection was 32,3 min. In English literature, we found only one study by S.W.Jung et al. compared this technique with cold or rapid dissection in the aspect of hepatic function. The study was proceeded in 44 BDDs totally, with 23 cases using warm dissection and 21 cases using cold dissection. The time of warm dissection was from 30 to 45 min; however, the total operative time was longer in cold dissection (700 min) compared to warm dissection (598 min), with no significant differentiation. The quantity of serum and blood transfusion in operation had no differentiation in two techniques. There were no differentiations in mortality and grafts' survival rate in two groups [18].

In our study, the rate of organ injury was lower than almost all other authors with a hepatic parenchymal injury rate of 3.92% and no vascular or biliary tract injury during organ procurement. There was only one case of over-shortened supra-hepatic vena cava during heart procurement requiring an angioplasty with a vena cava graft from the same donor. Anatomical injuries of liver grafts are vary among authors around the world, of which parenchymal injury was the most frequent with a rate of 0–20.7%, followed by injuries of the artery (0–15.4%), vein (0–7.7%), and biliary tract (0–2.5%). D. H. Jung et al. [14] designed a similar study on liver procurement from brain-dead donors with a hot dissection technique and showed that the parenchymal injuries of the graft were the majority. There were 7 cases (4.2%) of hepatic parenchymal injury; among them, mostly were of Glisson's capsule (6 cases). The graft injury rate seemed to be higher in studies using cool dissection techniques [19–21].

With over 10 years of experience with this technique, we had some recommendations:

- The warm dissection should be practiced by experiment surgeons to avoiding any damages of hilar components.
- In this technique, it is important to preserve the outermost layer of artery to avoiding blunt trauma, vasospasm, and thrombosis post-transplantation.
- Identification and control of all the elements of the hepatic hilum step – by – steps before dissection and perfusion were effective to avoiding any damages caused by the difficulty to differentiate hilar components without color as living characteristics.
- Identification and control of all the elements of the hepatic hilum in heart-beating phase help to reduce the cold ischemia time.
- Warm dissection could not replace the back-table dissection but help this step becomes fluent and advantaged.

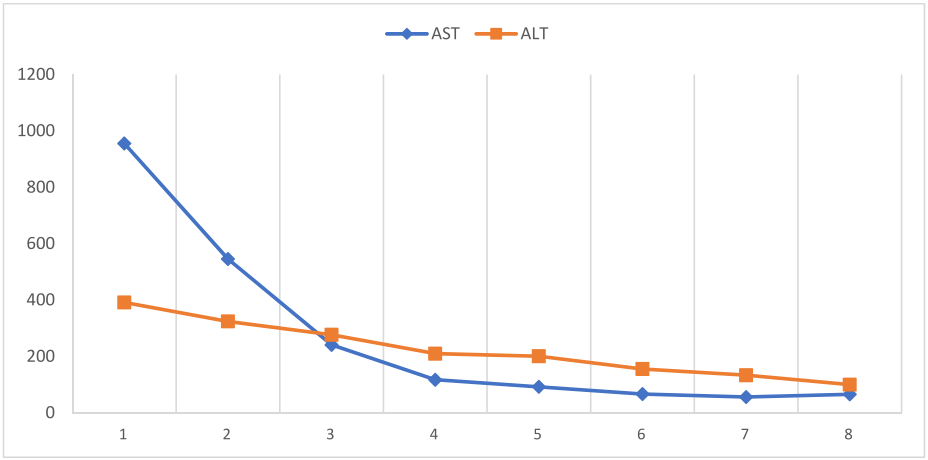

Chart 1. Progression of liver enzyme after transplant at 7 days and the last day.

Our study results on liver graft quality were inferior to Diaz Nieto et al.'s study [22] of 1299 cases underwent liver transplant at The Royal Free Hospital, London, of which among 1252 orthotopic liver transplantations were from cadaveric donors. The steatosis rate was only 18%, however, 4.9% had medium and 0.4% had severe steatosis. . Our steatosis rate was superior to S.W. Jung et al.'s [18] study with a large-droplet rate of 25–28% and a small-droplet rate of 32–41%. This result agreed with our younger study group rather than with S.W. Jung et al.'s group with an average age of 48 years.

Our study showed that the graft/body weight ratio was 2.3 ± 0.52 (%). This result was similar with one of S.W. Jung et al. [18] with 2.27 ± 1.6 (%) and other of D.H. Jung et al. [14] with 2.32 ± 0.61(%). Because the majority was orthotopic liver transplantation, the role of weight was not mentioned in many studies. The smallest liver graft in our study was 700 g in weight and enough to be transplanted into a 87.5-kg recipient.

In our study, no case of postoperative primary liver function disorder was reported. This was from a donor selection protocol with relatively strict criteria and the majority of donors met the ideal criteria. The rate of primary non-functional liver was 4.3% in Varotti et al.'s study [23] of 669 orthotopic liver transplantation from brain-dead donors. Our study showed that the mean peak of AST, ALT in the group of warm dissection technique were 955.1 U/L, 391.1 U/L, respectively, all elevated in day 1 then decreased and stabilized after 7 days. These findings are consistent with other studies in the world. Study of S.W. Jung [18] showed that AST decreased gradually from day 1 to day 5 then stabilize in the range of less than 100 UI/L, while ALT increased from day 2, gradually decreased and stabilized at day 7.

In our study, post-transplantation haemorrhage complications were seen in 3/52 cases (5.77%). This rate was lower than other studies from around the world; for example, Harald Schrem et al.'s study [17] of 770 liver transplantations (702 orthotopic and 68 split liver transplantation) had a haemorrhage complication rate of 19.9%. Risk factors were analysed and thought to be related to the amount of blood transfusion during the operation, hepatitis condition, MELD score, Prothrombin ratio, and the donor's length of stay in the ICU. Nijkamp [24] demonstrated that post-transplantation haemorrhage from parenchymal injuries during organ procurement was 18% (5/50), which is higher than that of the non-parenchymal injury group (9% or 5/28). All our haemorrhage cases did not relate to injury during organ procurement.

Our research was limited by resources and time. And with the pandemic of COVID-19, we are struggle with following-up patients. Moreover, we have challenges with quantity of brain-death donors because of Vietnamese culture with preserving body after death as well as limitations in resuscitation before procurement. In near future, we believe our technique can be applied widespread in other institutes of our country with the completion of Vietnam National Coordinating Center for Human Organ Transplantation – the officially national organization of organ coordination. We hope, with the development of this organization and our medical system generally, our research can be continuedly proceed and complete in near future to evaluate long-term outcomes of recipients (overall survival, quality of life, etc.).

5. Conclusions

Liver transplantation, especially in brain-dead donors, is a newly medical specialty, which is developed dramatically in recent several decades. There are quite several techniques that are developed and proceed referred to different institutions depend on experience of surgeons, as well as faculties of preoperative intensive care. In this study, we have described a novel technique of in vivo perfusion and warm dissection for organs retrieval in BDDs based on our experience in orthotopic liver transplantation. This technique can be applied to multiple organs procurement such as liver, kidneys, heart, and lungs retrieval with potential effects by reducing the cold ischemia time as well as minimizing the risk of grafts' damages with cold dissection. There needs to perform more studies with long-term follow-up to evaluating the proper value of this technique in grafts' quality and at last, in recipients' overall survival.

Ethical approval

The study was approved by the Research Ethics Committee of Hanoi Medical University. The procedures used in this study adhere to the tenets of the Declarations of Helsinki.

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Author contribution

Thanh Khiem NGUYEN: the main doctor conceived the original idea and operated the patients, wrote manuscript. Hong Son TRINH: the doctor conceived the original idea and operated the patients, summed up, revised manuscript. Tuan Hiep LUONG: operated the patients, followed up, wrote manuscript. Viet Khai NINH: operated the patients, summed up, revised manuscript. Gia Anh PHAM: operated the patients, summed up, revised manuscript. Ham Hoi NGUYEN: operated the patients, summed up, revised manuscript. Trung Nghia BUI: operated the patients, summed up, revised manuscript. Kim Khue DANG: operated the patients, summed up, revised manuscript. Tuan HOANG: operated the patients, summed up, revised manuscript. Quang Nghia NGUYEN: operated the patients, summed up, revised manuscript. All authors contributed to the interpretation of the results, discussed the results. All authors read and approved the final manuscript to submit.

Registration of research studies

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Consent

The patients have consented to the submission of the case report for submission to the journal.

Provenance and peer review

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Declaration of competing interest

The authors declare that they have no conflicts of interests.

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None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2021.102654.

Appendix

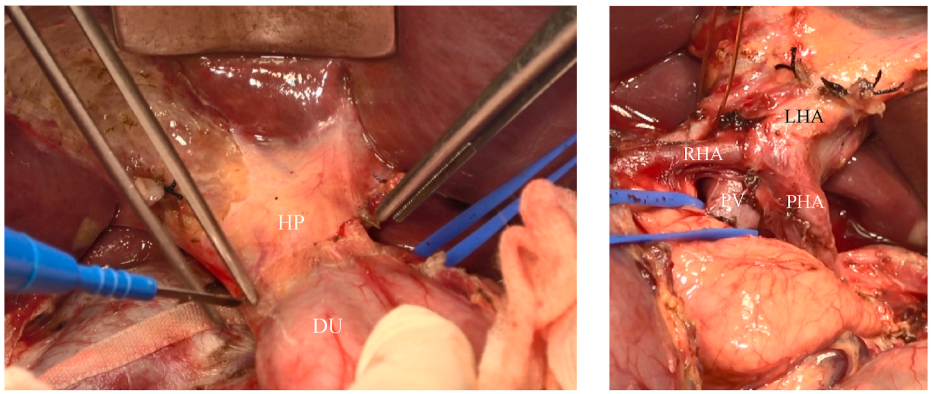

Fig. 1. Hepatic pedicle dissection (Patient Le Viet T.)* DU: Duodenum, HP: Hepatic pedicle, PHA: Proper hepatic artery, PV: Portal vein, RHA: Right hepatic artery, LHA: Left hepatic artery.

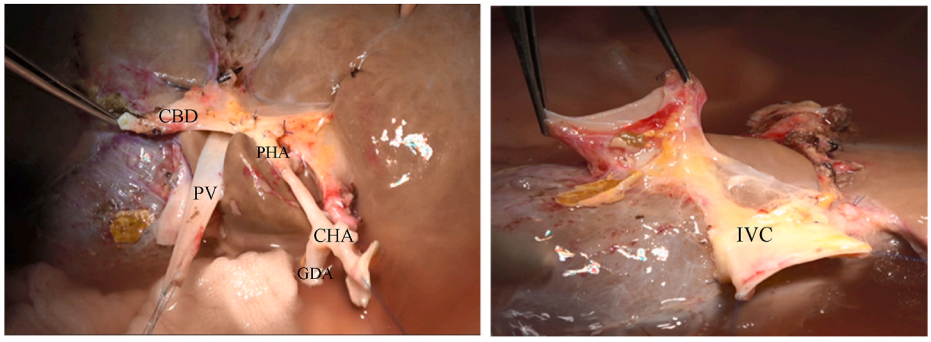

Fig. 2. Cold dissection of hepatic pedicle and vena cava in Back-table (Patient VU Thanh L.)* IVC: Inferior vena cava, CHA: Common hepatic artery, PHA: Proper hepatic artery, PV: Portal vein, GDA: Gastroduodenal artery.

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