

World Journal of *Gastroenterology*

World J Gastroenterol 2021 October 21; 27(39): 6515-6736



EDITORIAL

- 6515 Importance of *BRCA* mutation for the current treatment of pancreatic cancer beyond maintenance
Martinez-Galán J, Rodríguez I, Caba O

FRONTIER

- 6522 Acetyl-CoA carboxylase inhibitors in non-alcoholic steatohepatitis: Is there a benefit?
Neokosmidis G, Cholongitas E, Tziomalos K

REVIEW

- 6527 Therapeutic resistance in pancreatic ductal adenocarcinoma: Current challenges and future opportunities
Jain A, Bhardwaj V
- 6551 Evaluation of botanicals as potential COVID-19 symptoms terminator
Caliskan UK, Karakus MM

MINIREVIEWS

- 6572 Current and emerging therapeutic strategies in pancreatic cancer: Challenges and opportunities
Manrai M, Tilak TVSVGK, Dawra S, Srivastava S, Singh A
- 6590 Cathepsin L, transmembrane peptidase/serine subfamily member 2/4, and other host proteases in COVID-19 pathogenesis – with impact on gastrointestinal tract
Berdowska I, Matusiewicz M
- 6601 Endoscopic anti-reflux therapy for gastroesophageal reflux disease
Rodríguez de Santiago E, Albéniz E, Estremera-Arevalo F, Teruel Sanchez-Vegazo C, Lorenzo-Zúñiga V

ORIGINAL ARTICLE**Basic Study**

- 6615 Cold exposure and capsaicin promote 1,2-dimethylhydrazine-induced colon carcinogenesis in rats correlates with extracellular matrix remodeling
Qin JC, Yu WT, Li HX, Liang YQ, Nong FF, Wen B
- 6631 Detection and analysis of common pathogenic germline mutations in Peutz-Jeghers syndrome
Gu GL, Zhang Z, Zhang YH, Yu PF, Dong ZW, Yang HR, Yuan Y

Clinical and Translational Research

- 6647 Validation of the Italian translation of the perceived stigma scale and resilience assessment in inflammatory bowel disease patients

Cococcia S, Lenti MV, Mengoli C, Klersy C, Borrelli de Andreis F, Secco M, Ghorayeb J, Delliponti M, Corazza GR, Di Sabatino A

Retrospective Cohort Study

- 6659 Prognostic factors of minimally invasive surgery for gastric cancer: Does robotic gastrectomy bring oncological benefit?

Nakauchi M, Suda K, Shibasaki S, Nakamura K, Kadoya S, Kikuchi K, Inaba K, Uyama I

Observational Study

- 6673 Diagnostic usefulness of selected proteases and acute phase factors in patients with colorectal adenocarcinoma

Sebzda T, Gnus J, Dziadkowiec B, Latka M, Gburek J

- 6689 Impact of a colorectal cancer screening program implantation on delays and prognosis of non-screening detected colorectal cancer

Cubiella J, Lorenzo M, Baiocchi F, Tejido C, Conde A, Sande-Meijide M, Castro M

Prospective Study

- 6701 Standard liver weight model in adult deceased donors with fatty liver: A prospective cohort study

Li B, Chen PY, Tan YF, Huang H, Jiang M, Wu ZR, Jiang CH, Zheng DF, He D, Shi YJ, Luo Y, Yang JY

SYSTEMATIC REVIEWS

- 6715 Microbiota shaping – the effects of probiotics, prebiotics, and fecal microbiota transplant on cognitive functions: A systematic review

Baldi S, Mundula T, Nannini G, Amedei A

LETTER TO THE EDITOR

- 6733 Impact of COVID-19 pandemic on the neuropsychiatric status of Wilson's disease

Lanza G, Godani M, Ferri R, Raggi A

ABOUT COVER

Editorial Board Member of *World Journal of Gastroenterology*, José B Cotter, MD, PhD, Chief Doctor, Professor, Department of Gastroenterology, Hospital da Senhora da Oliveira, Rua dos Cutileiros, Creixomil, Guimarães 4835-044, Portugal. jcotter@hospitaldeguimaraes.min-saude.pt

AIMS AND SCOPE

The primary aim of *World Journal of Gastroenterology* (WJG, *World J Gastroenterol*) is to provide scholars and readers from various fields of gastroenterology and hepatology with a platform to publish high-quality basic and clinical research articles and communicate their research findings online. WJG mainly publishes articles reporting research results and findings obtained in the field of gastroenterology and hepatology and covering a wide range of topics including gastroenterology, hepatology, gastrointestinal endoscopy, gastrointestinal surgery, gastrointestinal oncology, and pediatric gastroenterology.

INDEXING/ABSTRACTING

The WJG is now indexed in Current Contents®/Clinical Medicine, Science Citation Index Expanded (also known as SciSearch®), Journal Citation Reports®, Index Medicus, MEDLINE, PubMed, PubMed Central, and Scopus. The 2021 edition of Journal Citation Report® cites the 2020 impact factor (IF) for WJG as 5.742; Journal Citation Indicator: 0.79; IF without journal self cites: 5.590; 5-year IF: 5.044; Ranking: 28 among 92 journals in gastroenterology and hepatology; and Quartile category: Q2. The WJG's CiteScore for 2020 is 6.9 and Scopus CiteScore rank 2020: Gastroenterology is 19/136.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: Yan-Xia Xing; Production Department Director: Xiang Li; Editorial Office Director: Ze-Mao Gong.

NAME OF JOURNAL

World Journal of Gastroenterology

ISSN

ISSN 1007-9327 (print) ISSN 2219-2840 (online)

LAUNCH DATE

October 1, 1995

FREQUENCY

Weekly

EDITORS-IN-CHIEF

Andrzej S Tarnawski, Subrata Ghosh

EDITORIAL BOARD MEMBERS

<http://www.wjgnet.com/1007-9327/editorialboard.htm>

PUBLICATION DATE

October 21, 2021

COPYRIGHT

© 2021 Baishideng Publishing Group Inc

INSTRUCTIONS TO AUTHORS

<https://www.wjgnet.com/bpg/gerinfo/204>

GUIDELINES FOR ETHICS DOCUMENTS

<https://www.wjgnet.com/bpg/GerInfo/287>

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH

<https://www.wjgnet.com/bpg/gerinfo/240>

PUBLICATION ETHICS

<https://www.wjgnet.com/bpg/GerInfo/288>

PUBLICATION MISCONDUCT

<https://www.wjgnet.com/bpg/gerinfo/208>

ARTICLE PROCESSING CHARGE

<https://www.wjgnet.com/bpg/gerinfo/242>

STEPS FOR SUBMITTING MANUSCRIPTS

<https://www.wjgnet.com/bpg/GerInfo/239>

ONLINE SUBMISSION

<https://www.f6publishing.com>

Prospective Study

Standard liver weight model in adult deceased donors with fatty liver: A prospective cohort study

Bo Li, Pan-Yu Chen, Yi-Fei Tan, He Huang, Min Jiang, Zhen-Ru Wu, Chen-Hao Jiang, Dao-Feng Zheng, Diao He, Yu-Jun Shi, Yan Luo, Jia-Yin Yang

ORCID number: Bo Li 0000-0003-2458-754X; Pan-Yu Chen 0000-0001-7416-8904; Yi-Fei Tan 0000-0001-8168-3971; He Huang 0000-0002-9439-9512; Min Jiang 0000-0002-0932-4904; Zhen-Ru Wu 0000-0001-5974-8265; Chen-Hao Jiang 0000-0001-5465-7743; Dao-Feng Zheng 0000-0002-2124-8377; Diao He 0000-0001-7379-4284; Yu-Jun Shi 0000-0003-0494-6023; Yan Luo 0000-0003-2985-1768; Jia-Yin Yang 0000-0001-9134-1959.

Author contributions: Li B and Chen PY contributed equally to this work; Li B collected all the clinical data, analyzed the data, drafted the manuscript and prepared the revised materials; Chen PY collected the data of donor liver weight in the operating room and assisted with data analysis; Tan YF analyzed the data, drafted the manuscript and prepared the revised materials; Huang H and Luo Y assisted with ultrasound examination and data processing; Wu ZR and Shi YJ helped with tissue staining and histological assessment; Zheng DF, He D and Jiang CH assisted with donor liver weight measurement and tissue sampling; Jiang M participated in design of the study, data processing and data analysis; Yang JY participated in design and oversight of the study and was

Bo Li, Yi-Fei Tan, Chen-Hao Jiang, Dao-Feng Zheng, Diao He, Jia-Yin Yang, Department of Liver Surgery, Liver Transplantation Centre, West China Hospital of Sichuan University, Chengdu 610041, Sichuan Province, China

Bo Li, Yi-Fei Tan, Chen-Hao Jiang, Dao-Feng Zheng, Diao He, Jia-Yin Yang, Laboratory of Liver Transplantation, Frontiers Science Center for Disease-related Molecular Network, West China Hospital of Sichuan University, Chengdu 610041, Sichuan Province, China

Pan-Yu Chen, Operating Room, West China Hospital, Sichuan University/West China School of Nursing, Sichuan University, Chengdu 610041, Sichuan Province, China

He Huang, Yan Luo, Department of Medical Ultrasound, West China Hospital of Sichuan University, Chengdu 610041, Sichuan Province, China

Min Jiang, Department of Epidemiology and Health Statistics, West China School of Public Health and West China Fourth Hospital, Sichuan University, Chengdu 610041, Sichuan Province, China

Zhen-Ru Wu, Yu-Jun Shi, Laboratory of Pathology, Key Laboratory of Transplant Immunology and Engineering, National Health Commission, West China Hospital of Sichuan University, Chengdu 610041, Sichuan Province, China

Corresponding author: Jia-Yin Yang, MD, PhD, Chief Doctor, Director, Professor, Surgeon, Department of Liver Surgery, Liver Transplantation Centre, West China Hospital of Sichuan University, No. 37 Guo Xue Xiang, Chengdu 610041, Sichuan Province, China.

doctoryjy@scu.edu.cn

Abstract**BACKGROUND**

Standard liver weight (SLW) is frequently used in deceased donor liver transplantation to avoid size mismatches with the recipient. However, some deceased donors (DDs) have fatty liver (FL). A few studies have reported that FL could impact liver size. To the best of our knowledge, there are no relevant SLW models for predicting liver size.

AIM

To demonstrate the relationship between FL and total liver weight (TLW) in detail

involved with drafting of the manuscript; all authors have read and approve the final manuscript.

Supported by New Clinical Technology Project, West China Hospital, Sichuan University, No. 20HXJS012; and National Natural Science Foundation of China, No. 81770653 and No. 82070674.

Institutional review board

statement: This study was reviewed and approved by the West China Hospital of Sichuan University Institutional Review Board.

Clinical trial registration statement:

This study was registered at <http://www.chictr.org.cn>. The registration identification number is ChiCTR2000041406.

Informed consent statement:

All study participants, or their legal guardians, provided informed written consent prior to study enrollment.

Conflict-of-interest statement: The authors of this manuscript have no conflicts of interest to disclose.

Data sharing statement: No additional data are available.

CONSORT 2010 statement: The authors have read the CONSORT 2010 Statement, and the manuscript was prepared and revised according to the CONSORT 2010 Statement.

Open-Access: This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

Manuscript source: Unsolicited

and present a related SLW formula.

METHODS

We prospectively enrolled 212 adult DDs from West China Hospital of Sichuan University from June 2019 to February 2021, recorded their basic information, such as sex, age, body height (BH) and body weight (BW), and performed abdominal ultrasound (US) and pathological biopsy (PB). The chi-square test and kappa consistency score were used to assess the consistency in terms of FL diagnosed by US relative to PB. Simple linear regression analysis was used to explore the variables related to TLW. Multiple linear regression analysis was used to formulate SLW models, and the root mean standard error and interclass correlation coefficient were used to test the fitting efficiency and accuracy of the model, respectively. Furthermore, the optimal formula was compared with previous formulas.

RESULTS

Approximately 28.8% of DDs had FL. US had a high diagnostic ability (sensitivity and specificity were 86.2% and 92.9%, respectively; kappa value was 0.70, $P < 0.001$) for livers with more than a 5% fatty change. Simple linear regression analysis showed that sex (R^2 , 0.226; $P < 0.001$), BH (R^2 , 0.241; $P < 0.001$), BW (R^2 , 0.441; $P < 0.001$), BMI (R^2 , 0.224; $P < 0.001$), BSA (R^2 , 0.454; $P < 0.001$) and FL (R^2 , 0.130; $P < 0.001$) significantly impacted TLW. In addition, multiple linear regression analysis showed that there was no significant difference in liver weight between the DDs with no steatosis and those with steatosis within 5%. Furthermore, in the context of hepatic steatosis, TLW increased positively (non-linear); compared with the TLW of the non-FL group, the TLW of the groups with hepatic steatosis within 5%, between 5% and 20% and more than 20% increased by 0 g, 90 g, and 340 g, respectively. A novel formula, namely, $-348.6 + (110.7 \times \text{Sex} [0 = \text{Female}, 1 = \text{Male}] + 958.0 \times \text{BSA} + (179.8 \times \text{FL}_{\text{US}} [0 = \text{No}, 1 = \text{Yes}]))$, where FL was diagnosed by US, was more convenient and accurate than any other formula for predicting SLW.

CONCLUSION

FL is positively correlated with TLW. The novel formula deduced using sex, BSA and FL_{US} is the optimal formula for predicting SLW in adult DDs.

Key Words: Standard liver weight; Body surface area; Fatty liver; Sex; Deceased donors

©The Author(s) 2021. Published by Baishideng Publishing Group Inc. All rights reserved.

Core Tip: This study was the first to explore the relationship between fatty liver (FL) and total liver weight (TLW) in detail using pathological biopsy based on adult deceased donors (DDs) and developed a new standard liver weight (SLW) formula. Moreover, to conveniently apply the SLW formula to the clinic, we introduced ultrasound (US). Notably, we found that FL was positively correlated with TLW and that US had a high diagnostic ability for mild to severe FL, which could increase liver weight significantly. The formula deduced using sex, BSA and FL_{US} is the optimal formula for predicting SLW in adult DDs.

Citation: Li B, Chen PY, Tan YF, Huang H, Jiang M, Wu ZR, Jiang CH, Zheng DF, He D, Shi YJ, Luo Y, Yang JY. Standard liver weight model in adult deceased donors with fatty liver: A prospective cohort study. *World J Gastroenterol* 2021; 27(39): 6701-6714

URL: <https://www.wjgnet.com/1007-9327/full/v27/i39/6701.htm>

DOI: <https://dx.doi.org/10.3748/wjg.v27.i39.6701>

INTRODUCTION

Standard liver weight (SLW) is a key parameter in liver surgery. Its accurate evaluation is the basis for patient safety in both hepatectomy and liver transplantation

manuscript

Specialty type: Transplantation**Country/Territory of origin:** China**Peer-review report's scientific quality classification**

Grade A (Excellent): 0

Grade B (Very good): B

Grade C (Good): 0

Grade D (Fair): 0

Grade E (Poor): 0

Received: June 20, 2021**Peer-review started:** June 20, 2021**First decision:** August 8, 2021**Revised:** August 22, 2021**Accepted:** September 16, 2021**Article in press:** September 16, 2021**Published online:** October 21, 2021**P-Reviewer:** Yang M**S-Editor:** Ma YJ**L-Editor:** A**P-Editor:** Liu JH

(LT). In hepatectomy, the underestimation of SLW may lead to residual liver failure[1, 2], and in living donor liver transplantation (LDLT)/split liver transplantation (SLT), the underestimation of SLW can lead to small-for-size syndrome (SFSS)[3-5]. Since the establishment of Urata's standard liver volume (SLV) model[6], approximately 14 SLV models have been published worldwide, most of which are based on healthy people, living donors and autopsy donors from various medical centres. Deceased donor liver transplantation (DDLT) is a crucial donor liver source for alleviating the shortage of donor livers. Subsequently, SLT was established and further expanded the donor liver pool. Previous studies[7-10] have reported that SLT is not inferior to whole liver transplantation in terms of patient prognosis, which has encouraged the extensive use of SLT and necessitated an urgent demand for an SLW formula for DDLT to avoid severe mismatches, large-for-size syndrome[11,12] or SFSS. Moreover, deceased donors (DDs) and living donors (LDs) are from the general population and may have hepatic steatosis, which has a reported global incidence of 15%-30%[13,14]. To our knowledge, fatty liver (FL) may be associated with marginal grafts, as severe steatosis is a risk factor related to graft survival[15] and may affect liver size[16,17]. However, these associations have not been quantified conclusively. To the best of our knowledge, only one model[18] has been published for DDs, and it was based on a Western population and did not address FL. Therefore, this study prospectively collected adult DDs' clinical data combined with FL parameters to develop an SLW model.

MATERIALS AND METHODS

The present study prospectively enrolled consecutive deceased liver donors from West China Hospital of Sichuan University from June 2019 to February 2021 and recorded basic patient information, such as sex, age, body height (BH) and body weight (BW). This study was reviewed and approved by the West China Hospital of Sichuan University Institutional Review Board and registered at <http://www.chictr.org.cn>. The registration identification number is ChiCTR2000041406. All the study participants, or their legal guardians, provided informed written consent prior to study enrollment, and the study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the ethics committee. No executed prisoners were included in the study. A total of 212 DDs were enrolled, and brain death was confirmed in all of them before organ procurement. Advanced life support was maintained in an intensive care unit (ICU); moreover, abdominal ultrasound (US) examinations, liver function tests and kidney function tests were completed for each donor. Pathological biopsy (PB) was performed for all enrolled donor livers after they were obtained.

US examination

A US examination was carried out for all DDs before organ procurement. Scanning and diagnosis were conducted by 2 experienced (> 5 years) US doctors who were blinded to the final PB diagnosis. The examinations were performed by using a MultiWave ultrasound system (Aixplorer, France) equipped with an SC6-1 (1-6 MHz) transducer. FL was identified as a diffuse increase in fine echoes in the liver parenchyma. Representative images[19] are presented in [Figure 1](#).

Donor liver weight measurement, tissue sampling and histological assessment

Donor livers were procured and trimmed in the operating room and were then weighed with a precision electronic balance (unit: kg, accurate to 0.001 kg, [Figure 2](#)) on a back table.

A single tissue wedge of approximately 1.0 cm × 1.0 cm × 1.0 cm was excised from the left lateral lobe surface of the donor liver, fixed in formalin and embedded in paraffin. Each donor liver was stained with haematoxylin and eosin (HE) and Masson's trichrome. The histological degree of liver pathology, including hepatic steatosis, ballooning of hepatocytes, lobular inflammation, necrosis, and fibrosis, was evaluated by two expert liver pathologists blinded to any other clinical information and laboratory data. The extent of hepatic steatosis was assessed by the percentage of hepatocytes containing large- and medium-sized intracytoplasmic lipid droplets (but not foamy microvesicles). The definition of ballooning of hepatocytes and lobular inflammation was as described by Kleiner *et al*[20] and Bedossa *et al*[21]. The definition of necrosis is described in [Table 1](#). Fibrosis was scored according to the standard grading (inflammation) and staging (fibrosis) method based on the modified Scheuer

Table 1 Characteristics of the deceased donors

| Characteristic | Total, n = 212 |
|--|---------------------|
| Sex, male, n (%) | 167 (78.8) |
| Age, median (range), yr | 49 (18–68) |
| BH, median (range), cm | 168 (150–185) |
| BW, median (range), kg | 65 (45–90) |
| BMI, median (range), kg/m ² | 23.35 (15.57–30.48) |
| BSA, median (range), m ² | 1.73 (1.37–2.10) |
| TLW, median (range), g | 1400 (830–2100) |
| Cause of death, n (%) | |
| Trauma | 106 (50.0) |
| Cerebrovascular | 97 (45.8) |
| Other | 9 (4.2) |
| Degree of fatty change, median (range) | 0 (0–40%) |
| 0, n (%) | 151 (71.2) |
| > 0, < 5%, n (%) | 32 (15.1) |
| 5%–33%, n (%) | 22 (10.4) |
| > 33%, n (%) | 7 (3.3) |
| Ballooning of hepatocytes | |
| None | 24 (11.1) |
| Ballooned hepatocyte with normal size | 116 (54.9) |
| Enlarged ballooned hepatocyte | 72 (34.0) |
| Lobular inflammation | |
| None | 66 (30.9) |
| < 2 foci per lobule | 131 (61.7) |
| > 2 foci per lobule | 15 (7.4) |
| Necrosis | |
| None | 200 (94.4) |
| Focal or unicellular necrosis | 8 (3.7) |
| More extensive necrosis and above | 4 (1.9) |
| Stage of fibrosis ¹ | |
| 0 | 72 (33.8) |
| 1 | 88 (41.6) |
| 2 | 47 (22.1) |
| 3 | 4 (1.9) |
| 4 | 1 (0.6) |

¹According to the modified Scheuer system[22]. BH: Body height; BW: Body weight; BMI: Body mass index; BSA: Body surface area; TLW: Total liver weight.

system[22].

Estimating SLW using previous formulas

According to previous studies at our centre[23] and other centres[24–26], the density of the liver was determined to be 1 g/cm³; that is, the weight and volume of the donor liver were equal. For comparison, we calculated the estimated SLW according to

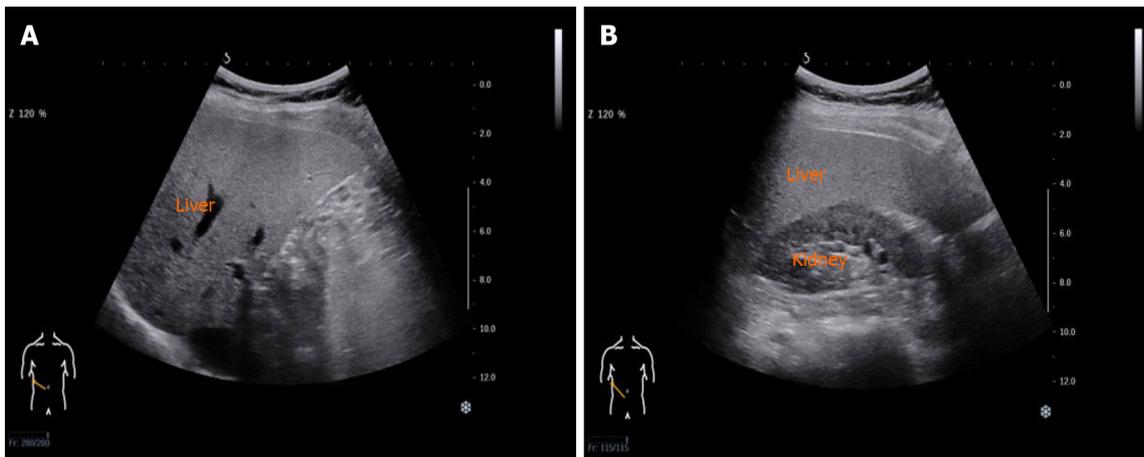


Figure 1 Diagram of fatty liver diagnosed by ultrasound from the view of the liver and kidney. A: Diffuse increase in fine echoes in liver parenchyma with normal visualization of intrahepatic vessel borders; B: Diffuse increase in fine echoes in liver parenchyma. There was an increase in echogenicity of the liver compared with the echogenicity of the renal cortex.

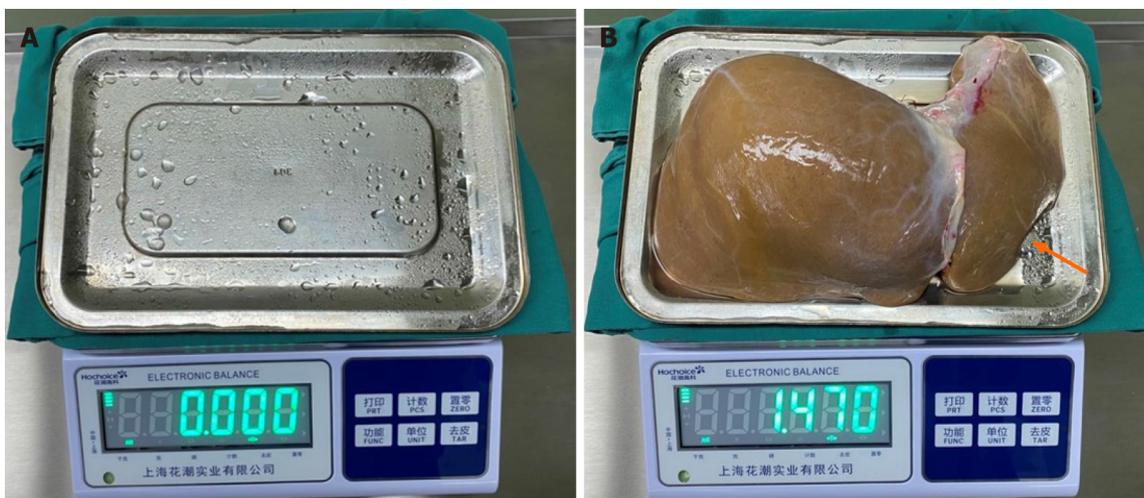


Figure 2 Actual liver weight measurement by electronic balance. A: Zero correction of electronic balance; B: Donor liver weighing. The arrow indicates that a single tissue wedge of approximately 1.0 cm × 1.0 cm × 1.0 cm was excised from the left lateral lobe surface of the donor liver.

previous formulas for adults[6-19]. Body mass index (BMI) = BW/BH² and body surface area (BSA) = BW^{0.425} × BH^{0.725} × 0.007184 using the Dubois formula[27] were also calculated.

Statistical analysis

In this study, simple linear regression analysis was used to explore the variables related to TLW. Multiple linear regression analysis was used to formulate the SLW. As BH, BW, BMI and BSA are collinear variables, each was applied in a different prediction model. The root mean standard error (RMSE) and interclass correlation coefficient (ICC) were used to test the fitting efficiency and accuracy of the model, respectively. The chi-square test and kappa consistency score were used to assess the consistency in terms of FL diagnosed by US relative to PB. Continuous variables were analysed by a paired-samples *t* test. Two-tailed statistical analysis was used, and *P* values less than 0.05 were considered to be statistically significant. SPSS, version 25.0 (IBM, Armonk, NY, United States) was used for all statistical analyses. GraphPad Prism 7.0 (GraphPad Software, Inc.) was used for drawing.

RESULTS

Baseline data

This study included 167 males (78.8%). The median age was 49 years, ranging from 18 to 68 years. The median BH, BW, BMI, BSA and TLW were 1.68 m, 65 kg, 23.35 kg/m², 1.73 m² and 1400 g, respectively. The main causes of death of the DDs were trauma (50%), cerebrovasculature (45.8%), and other (4.2%), which included brain tumours and hypoxic-ischaemic encephalopathy. There were 151 DDs (71.2%) with no steatosis, 32 (15.1%) with steatosis within 5%, 22 (10.4%) with steatosis between 5% and 33%, and 7 (3.3%) with steatosis greater than 33%. Moreover, hepatocyte ballooning was observed in 88.9% of DDs. Lobular inflammation was observed in approximately 69.1% of DDs. Necrosis (focal or unicellular necrosis, in 3.7% of DDs samples, and more extensive necrosis, in 1.9% of DDs samples) was observed in only a few DDs liver tissue samples. Stage 0–2 Liver fibrosis was observed in approximately 97.5% of DDs (Table 1).

Impact factors related to the TLW of deceased donors

Simple linear regression analysis showed that sex, BH, BW, BMI, BSA and FL significantly impacted TLW ($P < 0.001$) (Table 2). BSA was the most influential factor related to liver size [R^2 , 0.454; 95% confidence interval (CI): 1024.56–1383.79]. Multiple linear regression analysis showed that there was no significant difference in TLW between no steatosis and steatosis within 5% ($P = 0.147$, Figure 3A). Furthermore, in the context of hepatic steatosis, TLW increased positively (non-linear); compared with the TLW of the non-FL group, the TLW of the groups with hepatic steatosis within 5%, between 5% and 20% and more than 20% increased by 0 g, 90 g, and 340 g, respectively (Figure 3B).

Consistency test for FL diagnosis between US and PB

This study investigated 61 hepatic steatosis cases, which accounted for 28.8% of all cases, and moderate and severe steatosis cases, which accounted for 3.3%. The cases of hepatic steatosis and non-hepatic steatosis diagnosed by US were 38 and 174, respectively. The sensitivity and specificity of US were 55.7% and 97.4%, respectively, and the kappa value was 0.598 ($P < 0.001$). That is, its diagnostic consistency was good (Supplementary Table 1). Furthermore, when setting 5% as the cut-off value for diagnosing FL by PB, there were 174 cases within a 5% fatty change and 38 cases with more than a 5% fatty change diagnosed by US, with a sensitivity and specificity of 86.2% and 92.9%, respectively, and a kappa value of 0.70 ($P < 0.001$). Therefore, the diagnostic consistency between US and PB was high (Table 3).

Current formulas for estimating SLW

The SLW models were separately formulated based on four collinear variables, namely, BH, BW, BMI and BSA. Subsequently, three prediction model groups were established, two of which were used to assess the presence of FL based on US or PB; the third group did not include FL as an indicator. The present study showed that the SLW models based on BSA, FL and sex had the best fitness, and the adjusted R^2 and RMSE for PB and US were 0.546 and 169.985 and 0.546 and 169.913, respectively. The fitting efficiency of these two models was almost equal and better than that of the traditional method (adjusted R^2 , 0.485; RMSE, 181.095) (Table 4).

Comparison between the current formula and previous formulas

Previously reported formulas were used to assess our DDs cohort, and the results showed that the fitting efficiency and accuracy of the SLW model introducing FL diagnosed by US were 168.3 (RMSE) and 0.71 (ICC), with a non-significant difference ($P = 1.00$) between the SLW and TLW of 1.5 g. The RMSE and ICC of Yu *et al* [25]'s and Lin *et al* [28]'s models were 187.5 and 0.61 and 188.0 and 0.63, respectively. There were no significant differences between the SLW and actual TLW for these two formulas, but those of the remaining formulas were significantly different (Table 5) [6,18,25–37].

DISCUSSION

The shortage of donor livers is a problem worldwide and has become a major obstacle hindering the development of LT. To date, experts in the LT field have explored expanding the donor liver pool, including *via* SLT, marginal donor LT, domino LT and

Table 2 Factors related to the total liver weight of the deceased donors

| Factor | R ² | P value | 95%CI |
|--|----------------|---------|-----------------|
| Sex | 0.226 | < 0.001 | 220.89–369.68 |
| BH | 0.241 | < 0.001 | 13.92–22.78 |
| BW | 0.441 | < 0.001 | 15.25–20.77 |
| BSA | 0.454 | < 0.001 | 1024.56–1383.79 |
| BMI | 0.224 | < 0.001 | 32.28–54.18 |
| Degree of fatty change (< 5%, 5%–20%, > 20%) | 0.130 | < 0.001 | 116.89–244.17 |
| Hepatic steatosis ¹ | 0.125 | < 0.001 | 149.67–318.33 |

¹Diagnosed by ultrasound. BH: Body height; BW: Body weight; BSA: Body surface area; BMI: Body mass index.

Table 3 Results for livers with more than 5% fatty change diagnosed by ultrasound and pathological biopsy in the deceased donors

| Ultrasound | Pathological biopsy | | Total |
|------------|---------------------|-----|-------|
| | + | - | |
| + | 25 | 13 | 38 |
| - | 4 | 170 | 174 |
| Total | 29 | 183 | 212 |

According to the table above, livers with a fatty change of more than 5% were diagnosed by ultrasound, and the sensitivity and specificity were 86.2% and 92.9%, respectively. The chi-square test showed that the kappa value was 0.70, $P < 0.001$.

so on. These schemes have successfully and significantly expanded the donor liver pool, and SLT has become one of the most valuable means of promotion. Graft weight (GW) plays a key role in recipients, especially in DDLT and LDLT. Therefore, it is necessary to evaluate the donor liver size in LT.

DDs are patients with brain death caused by non-liver diseases. This study illustrated that 95.8% of DDs died from trauma or cardiovascular and cerebrovascular accidents. Biopsies showed that many donor livers had hepatocyte oedema and lobular inflammation, which can be explained by the cause of death. Trauma and cardiovascular and cerebrovascular accidents can cause instability of the circulatory system, leading to long-term ICU stays and the requirement for resuscitative therapy, which may cause unstable organ perfusion (hypoperfusion or hyperperfusion) and reperfusion injury. In addition, the use of a large number of vasoactive drugs may aggravate organ microcirculation disorder. Thus, the graft may have acute injury, such as lobular inflammation, hepatocyte oedema and even necrosis. The present study found that 28.8% of DDs had hepatic steatosis and that 2.5% had stage 3–4 Liver fibrosis. Unlike DDs, LDs screened from healthy populations rarely have FL or other acute liver injuries. In addition, it was unclear whether there was a difference in the SLW between DDs and LDs. To the best of our knowledge, there have been few relevant reports. Therefore, we explored the SLW model based on DDs data derived from West China Hospital.

Simple linear regression analysis showed that liver size was correlated with sex. The liver size of males was larger than that of females, which was in line with previous studies[30,33]. We speculated that this might be related to the fact that the body size of men is generally larger than that of women and that men have a larger skeletal muscle system and higher daily consumption and metabolic requirements. Therefore, a larger liver mass is needed to meet physiological needs[38,39]. In addition, the present study found that BH, BW, BMI and BSA were closely related to liver size, which was similar to previous studies[6,25,31,40]. Indeed, multiple linear regression analysis revealed that the above four variables were collinear. From the perspective of morphology, liver size and physical indicators are supposed to be positively correlated. Moreover, in terms of energy requirements, to meet metabolic needs, a larger body size needs more organ support. Furthermore, the current study found that BSA was the most influential factor impacting TLW, which was consistent with previous studies[6,29,

Table 4 Results of multiple linear regression analysis performed to predict the total liver weight using each of the body anthropometric measures divided into groups of the traditional method and two new methods, which introduce the parameter of fatty liver diagnosed by ultrasound and pathological biopsy

| Groups | Formulas | Adjusted R ² | RMSE |
|--|---|-------------------------|-------|
| Traditional method | | | |
| BH | $-809.4 + 167.3 \times \text{Sex} + 12.6 \times \text{BH}$ | 0.29 | 212.0 |
| BW | $322.1 + 147.0 \times \text{Sex} + 15.2 \times \text{BW}$ | 0.49 | 181.1 |
| BSA | $-466.9 + 99.0 \times \text{Sex} + 1051.0 \times \text{BSA}$ | 0.48 | 182.8 |
| BMI | $329.2 + 264.5 \times \text{Sex} + 37.8 \times \text{BMI}$ | 0.39 | 196.5 |
| Ultrasound method | | | |
| BH | $-1011.9 + 149.7 \times \text{Sex} + 13.6 \times \text{BH} + 240.7 \times \text{FL}_{\text{US}}$ | 0.43 | 191.1 |
| BW | $392.7 + 158.3 \times \text{Sex} + 13.5 \times \text{BW} + 158.6 \times \text{FL}_{\text{US}}$ | 0.54 | 171.4 |
| BSA | $-348.6 + 110.7 \times \text{Sex} + 958.0 \times \text{BSA} + 179.8 \times \text{FL}_{\text{US}}$ | 0.55 | 169.9 |
| BMI | $453.7 + 264.5 \times \text{Sex} + 31.2 \times \text{BMI} + 162.9 \times \text{FL}_{\text{US}}$ | 0.45 | 187.5 |
| Pathological biopsy method (< 5%, 5%–20%, > 20%) | | | |
| BH | $-803.7 + 178.5 \times \text{sex} + 12.3 \times \text{BH} + \text{FL}_{\text{PB}}$ (0 = 0, 1 = 163.5, 2 = 393.0) | 0.43 | 190.0 |
| BW | $414.5 + 172.6 \times \text{sex} + 13.1 \times \text{BW} + \text{FL}_{\text{PB}}$ (0 = 0, 1 = 79.8, 2 = 280.7) | 0.54 | 170.8 |
| BSA | $-288.8 + 129.5 \times \text{sex} + 919.6 \times \text{BSA} + \text{FL}_{\text{PB}}$ (0 = 0, 1 = 93.9, 2 = 304.5) | 0.55 | 170.0 |
| BMI | $478.1 + 276.5 \times \text{Sex} + 30.0 \times \text{BMI} + \text{FL}_{\text{PB}}$ (0 = 0, 1 = 105.3, 2 = 299.1) | 0.46 | 185.4 |

Sex and FL_{US} are binary variables; FL_{PB} is a dummy variable. Sex: 0 = Female, 1 = Male; FL_{US}: 0 = No, 1 = Yes; FL_{PB}: 0 < 5%, 1 = 5%–20%, 2 > 20%. BH: Body height; BW: Body weight; BSA: Body surface area; BMI: Body mass index; FL_{US}: Fatty liver diagnosed by ultrasound; FL_{PB}: Fatty liver diagnosed by pathological biopsy; RMSE: Root mean standard error.

31]. BSA is a widely used parameter in physiology and clinical medicine for normalizing biological function with respect to variations in body size and conformation. Thus, we believe that the liver size required to meet the metabolic demands of the individual may correlate more closely with BSA than with any other parameter. Additionally, previous studies[30,34] reported that age was associated with TLW; however, similar to Poovathumkadavil's study[35], we failed to identify an association between age and TLW. Several previous studies[31,40] reported that the partial regression coefficient of age was very small, and the authors considered the effect of this variable in adults to be negligible. Therefore, our negative result may be explained by the age distribution of patients in our study and the sample size, and further studies with larger sample sizes are needed to confirm the relation between age and TLW.

Interestingly, this study found that more than a quarter of DDs from the general population had hepatic steatosis, which was similar to Zhou *et al*[41]'s report (29.2%). To our knowledge, an increasing number of individuals, especially those who are obese, suffer from FL worldwide[42,43]. Furthermore, the present study also found that 10.4% and 3.3% of livers had mild and moderate steatosis, respectively, while no liver was detected to have severe steatosis. Several studies have confirmed that mild steatosis grafts (< 33%) can be used safely in LT. However, the eligibility of livers with moderate steatosis is controversial, while livers with severe steatosis are generally discarded because of the increased probability of primary non-function[15,44,45]. Importantly, in the current study, simple linear regression analysis demonstrated that FL was correlated with TLW. Moreover, multivariate analysis showed that steatosis significantly affected TLW, and the degree of steatosis was positively correlated with liver size, which was consistent with previous studies[16,46,47]. Multiple linear regression analysis showed that compared with non-FLs, the presence of hepatic steatosis within 5%, 5%–20% and over 20% resulted in an increase in liver weight by 0 g, 93.9 g, and 304.5 g, respectively. In LT, we generally evaluate the feasibility of SLT

Table 5 Differences between the estimated and actual liver weights calculated using previous formulas in our deceased donor cohort.

| Ref. | Formula | Difference ¹ (g) | RMSE | ICC | P value ² |
|--|---|-----------------------------|-------|------|----------------------|
| Autopsy | | | | | |
| DeLand <i>et al</i> [29] | $1020 \times \text{BSA} - 220$ | 135.5 (-366-632) | 221.2 | 0.52 | < 0.01 |
| Heinemann <i>et al</i> [26] | $1072.8 \times \text{BSA} - 345.7$ | 95 (-421-556) | 202.5 | 0.56 | < 0.01 |
| Yu <i>et al</i> [25] | $21.585 \times \text{BW}^{0.732} \times \text{BH}^{0.225}$ | 34.5 (-490-576) | 187.5 | 0.61 | 0.102 |
| Choukèr <i>et al</i> [30] | [16-50 yr] $452 + 16.34 \times \text{BW} + 11.85 \times \text{age} - 166 \times \text{sex}$ (1 = female, 0 = male) 51-70 yr $1390 + 15.94 \times \text{BW} - 12.86 \times \text{age}$ | 435 (-301-1000) | 484.0 | 0.24 | < 0.01 |
| General population/living donor | | | | | |
| Urata[6] | $706.2 \times \text{BSA} + 2.4$ | -185 (-713-337) | 278.1 | 0.32 | < 0.01 |
| Lin <i>et al</i> [28] | $13 \times \text{BH} + 12 \times \text{BW} - 1530$ | 11.5 (-546-445) | 188.0 | 0.63 | 0.472 |
| Vauthey <i>et al</i> [31] ³ | $1267.28 \times \text{BSA} - 794.41$ | -15 (-544-421) | 188.1 | 0.64 | < 0.01 |
| Hashimoto <i>et al</i> [32] | $961.3 \times \text{BSA} - 404.8$ | -161 (-668-317) | 253.4 | 0.42 | < 0.01 |
| Chan <i>et al</i> [33] | $218 + \text{BW} \times 12.3 + \text{sex} \times 51$ (0 = female, 1 = male) | -356.5 (-859-175) | 411.1 | 0.21 | < 0.01 |
| Yuan <i>et al</i> [34] | $949.7 \times \text{BSA} - 247.4 - 48.3 \times \text{age factor}$ (1, < 40; 2, 41-60; 3, > 60) | -106 (-646-359) | 228.0 | 0.48 | < 0.01 |
| Fu-Gui <i>et al</i> [23] | $11.508 \times \text{BW} + 334.024$ | -319 (-845-241) | 393.6 | 0.19 | < 0.01 |
| Poovathumkadavil <i>et al</i> [35] | $12.26 \times \text{BW} + 555.65$ | -57 (-572-510) | 207.5 | 0.47 | < 0.01 |
| Um <i>et al</i> [36] | $893.485 \times \text{BSA} - 439.169$ | -312.5 (-816-173) | 372.8 | 0.24 | < 0.01 |
| Cadaveric population | | | | | |
| Yoshizumi <i>et al</i> [18] ³ | $772 \times \text{BSA}$ | -79 (-602-416) | 214.6 | 0.45 | < 0.01 |
| Current | $-348.6 + 110.7 \times \text{Sex}$ (0 = Female, 1 = Male) + $958.0 \times \text{BSA} + 179.8 \times \text{FL}_{\text{US}}$ (0 = No, 1 = Yes) | 1.5 (-477.0-450.0) | 168.3 | 0.71 | 1 |

¹Difference between estimated and actual liver weight using previous formulas.

²Paired-samples *t* test.

³Mosteller's formula[37] was adopted for BSA, and the remaining formulas used the Dubois formula[27].

BH: Body height; BW: Body weight; BSA: Body surface area; BMI: Body mass index; FL_{US}: Fatty liver diagnosed by ultrasound; ICC: Interclass correlation coefficient; RMSE: Root mean standard error.

based on the criteria of GW/SLW (30%-40%) or GW/BW (0.8%)[11]. Thus, for FL, the GW required for recipients would be underestimated if calculated according to the traditional SLV method, leading to an increased risk of SFSS. Therefore, the current study introduced the FL variable for the first time to develop an SLW model. To diagnose FL before organ procurement, US was performed for all DDs. Notably, for a diagnosis of mild steatosis and greater ($\geq 5\%$), the sensitivity and specificity of US were 86.2% and 92.9%, respectively, and the ICC was 0.70 ($P < 0.001$). That is, US had a higher diagnostic consistency with PB. In addition, this study revealed that the size of livers with a fatty change less than 5% was not different from that of livers without fatty change but was different from that of livers with a fatty change of 5% or greater. The gap of liver size between these two hepatic steatosis categories was significant (180 g, $P < 0.001$), which laid a solid theoretical foundation to apply US in the diagnosis of FL and develop the SLW model, highlighting its clinical practical value.

In this study, the deduced best fit formula based on US had equivalence with that based on PB and was better than the best fit traditional model. Furthermore, the present study showed that the formulas of Deland *et al*[29], Heinemann *et al*[26], and Choukèr *et al*[30] overestimated liver size, while the formulas of Urata *et al*[6], Vauthey *et al*[31], Yoshizumi *et al*[18], Hashimoto *et al*[32], Chan *et al*[33], Yuan *et al*[34], Fu Gui *et al*[23], Poovathumkadavil *et al*[35], and Um *et al*[36] underestimated liver size. On the other hand, there was no significant difference between the actual liver weight and the predicted liver weight calculated by Yu *et al*[25]'s and Lin *et al*[28]'s formulas. This was speculated to be related to the characteristics of the study samples. Deland *et al* [29]'s, Heinemann *et al*[26]'s and Choukèr *et al*[30]'s cohorts were autopsy samples. To

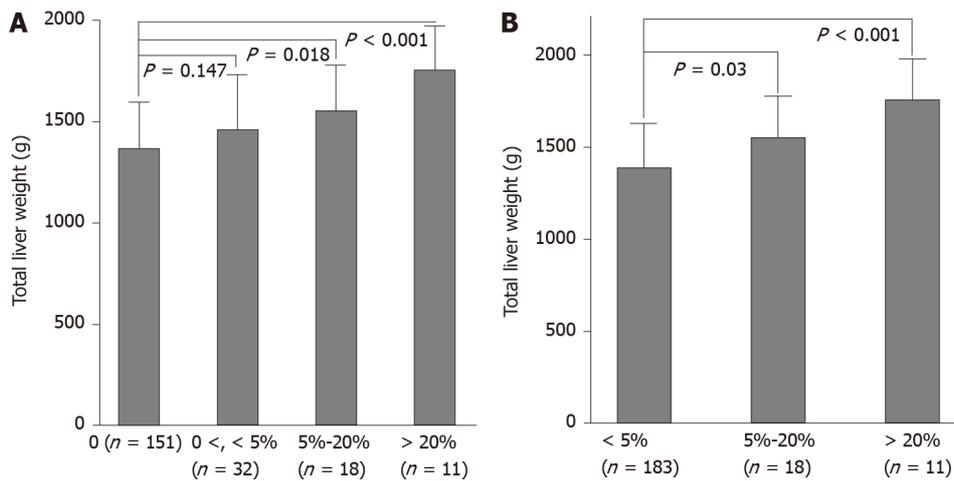


Figure 3 Total liver weight comparison of different groups according to the degree of fatty change of donor livers. A: Groups according to the degree of fatty change of 0, (0 < 5%), (5%–20%) and > 20%; B: Groups according to the degree of fatty change of < 5%, (5%–20%) and > 20%. Multiple linear regression analysis including parameters of sex, BSA, and FL_{PB}, which were dummy variables divided into groups according to the degree of fatty change in donor livers, was used. FL_{PB}, fatty liver diagnosed by pathological biopsy.

our knowledge, data from autopsy studies[29] includes the weight of the gallbladder, the attached ligaments, and the hepatic vena cava. In addition, various causes of death, *i.e.*, cardiac failure and traffic accidents, might increase liver weight through mechanisms associated with shock-related hepatic congestion. On the other hand, due to long-term immersion in the fixed solution, the weight of the specimen may exceed the actual size *in vivo*. However, the autopsy study of Yu *et al*[25] was not consistent with the other three autopsy studies but was similar to our study, which may be explained by racial differences. Additionally, the cohorts of Vauthey *et al*[31], Hashimoto *et al*[32], Chan *et al*[33], Yuan *et al*[34], Fu Gui *et al*[23], Poovathumkadavil *et al*[35], and Um *et al*[36] were based on healthy populations without liver disease. However, Lin *et al*[28]'s study cohort comprised 44 (57.1%) patients with chronic liver disease (alcoholic hepatitis, 9; hepatitis B, 24; and hepatitis C, 11), which may explain the difference from other studies based on the general population. Notably, the difference was significant between actual liver weight and estimated liver weight using the formula of Yoshizumi *et al*[18], which was the only previous study based on a cadaveric population. Their study included DDs of several races, most of which were Western, and subjects under 18 years were enrolled. These confounding factors may explain the difference. Therefore, for different study populations, the model for predicting liver size is supposed to be different, which highlights the need for this study for adult DDs. In addition, this study shows the practicability and rationality of the current SLW model in DDLT. Theoretically, it suggests that the current formula is the most suitable for recipients assigned with FL in SLT, and use of this formula is anticipated to reduce the risk of SFSS.

However, the sample size of this study was relatively small, especially in regard to cases of moderate to severe hepatic steatosis. Therefore, studies with larger sample sizes are warranted to optimize the SLW model. Additionally, the extrapolation and clinical practicability of the current SLW model need to be further verified.

CONCLUSION

In conclusion, this study was the first to demonstrate the positive correlation between the degree of hepatic steatosis and liver size based on pathological findings. Furthermore, this study creatively proposed and verified the equivalent value of FL diagnosed by US instead of that diagnosed by PB in terms of the FL variable in the SLW model as follows: SLW (g) = -348.6 + [110.7 × Sex (0 = Female, 1 = Male)] + 958.0 × BSA + [179.8 × FL_{US} (0 = No, 1 = Yes)]. This formula can be used to estimate the liver weight before liver procurement. Additionally, our formula lays a theoretical and practical basis for the further application of donor livers with fatty changes in SLT.

ARTICLE HIGHLIGHTS

Research background

Standard liver weight (SLW) is frequently used in liver transplantation, especially for living donor liver transplantation/split liver transplantation (SLT). However, some deceased donors (DDs) have fatty liver (FL). There have been a few studies to report that FL could impact liver size. This study was to develop a new formula including FL to predict liver size.

Research motivation

To explore SLW model in adult DDs with FL and help transplant doctors make allocation decisions, especially for recipients assigned with FL in SLT to reduce the risk of small-for-size syndrome.

Research objectives

To explore the liver pathology of DDs, such as hepatic steatosis, and diagnostic ability of ultrasound for FL, as well as the relationship between FL and total liver weight. Furthermore, to develop an SLW formula, combined with FL parameter, used to predict graft weight required for recipients in SLT.

Research methods

This study prospectively enrolled consecutive DDs from West China Hospital of Sichuan University from June 2019 to February 2021 and recorded basic patient information, and abdominal ultrasound (US) examination and pathological biopsy (PB) were performed for them. Furthermore, the chi-square test and kappa consistency score were used to assess the consistency in terms of FL diagnosed by US relative to PB. Simple linear regression analysis was used to explore the variables related to TLW. Multiple linear regression analysis was used to formulate SLW models.

Research results

More than a quarter of DDs had hepatic steatosis, and US had a high diagnostic ability for mild to severe FL. Furthermore, this study found that FL was positively correlated with liver size and deduced an optimal SLW formula in adult DDs with FL. However, the extrapolation and clinical practicability of the current SLW model need to be further verified in the future.

Research conclusions

FL is positively correlated with liver size. Our novel formula deduced using sex, BSA and FL_{US} is the optimal formula for predicting SLW in adult DDs with FL.

Research perspectives

To verify the extrapolation of the current SLW model using multicentre data and its clinical practicability in SLT.

ACKNOWLEDGEMENTS

We gratefully acknowledge Dr. Qi-Qi Zhou (Institute of Clinical Pathology, West China Hospital of Sichuan University, Chengdu 610041, Sichuan Province, China) for helping us scan pathological sections and process data. We gratefully acknowledge Dr. Min Jiang (Department of Epidemiology and Health Statistics, West China School of Public Health and West China Fourth Hospital, Sichuan University, Chengdu 610041, Sichuan Province, China) for reviewing the statistical methods of this study.

REFERENCES

- 1 **Ribero D**, Amisano M, Bertuzzo F, Langella S, Lo Tesoriere R, Ferrero A, Regge D, Capussotti L. Measured versus estimated total liver volume to preoperatively assess the adequacy of the future liver remnant: which method should we use? *Ann Surg* 2013; **258**: 801-806; discussion 806 [PMID: 24045451 DOI: 10.1097/SLA.000000000000213]
- 2 **Mullen JT**, Ribero D, Reddy SK, Donadon M, Zorzi D, Gautam S, Abdalla EK, Curley SA, Capussotti L, Clary BM, Vauthey JN. Hepatic insufficiency and mortality in 1,059 noncirrhotic

- patients undergoing major hepatectomy. *J Am Coll Surg* 2007; **204**: 854-862; discussion 862 [PMID: 17481498 DOI: 10.1016/j.jamcollsurg.2006.12.032]
- 3 **Dahm F**, Georgiev P, Clavien PA. Small-for-size syndrome after partial liver transplantation: definition, mechanisms of disease and clinical implications. *Am J Transplant* 2005; **5**: 2605-2610 [PMID: 16212618 DOI: 10.1111/j.1600-6143.2005.01081.x]
 - 4 **Soejima Y**, Taketomi A, Yoshizumi T, Uchiyama H, Harada N, Ijichi H, Yonemura Y, Shimada M, Maehara Y. Feasibility of left lobe living donor liver transplantation between adults: an 8-year, single-center experience of 107 cases. *Am J Transplant* 2006; **6**: 1004-1011 [PMID: 16611337 DOI: 10.1111/j.1600-6143.2006.01284.x]
 - 5 **Emond JC**, Renz JF, Ferrell LD, Rosenthal P, Lim RC, Roberts JP, Lake JR, Ascher NL. Functional analysis of grafts from living donors. Implications for the treatment of older recipients. *Ann Surg* 1996; **224**: 544-552; discussion 552 [PMID: 8857858 DOI: 10.1097/00000658-199610000-00012]
 - 6 **Urata K**, Kawasaki S, Matsunami H, Hashikura Y, Ikegami T, Ishizone S, Momose Y, Komiyama A, Makuuchi M. Calculation of child and adult standard liver volume for liver transplantation. *Hepatology* 1995; **21**: 1317-1321 [PMID: 7737637]
 - 7 **Park GC**, Hwang S, Song GW, Jung DH, Ha TY, Ahn CS, Moon DB, Kim KH, Yoon YI, Kang WH, Cho HD, Choi JU, Kim M, Na BG, Kim SH, Lee SG. Prognosis of Split Liver Transplantation Compared with Whole Liver Transplantation in Adult Patients: Single-center Results under the Korean MELD Score-based Allocation Policy. *J Korean Med Sci* 2020; **35**: e304 [PMID: 32959541 DOI: 10.3346/jkms.2020.35.e304]
 - 8 **Cherukuru R**, Reddy MS, Shanmugam NP, Rajalingam R, Kota V, Gunasekaran V, Narasimhan G, Kaliamoorthy I, Rela M. Feasibility and Safety of Split-Liver Transplantation in a Nascent Framework of Deceased Donation. *Liver Transpl* 2019; **25**: 450-458 [PMID: 30586233 DOI: 10.1002/lt.25405]
 - 9 **Valentino PL**, Emre S, Geliang G, Li L, Deng Y, Mulligan D, Rodriguez-Davalos MI. Frequency of whole-organ in lieu of split-liver transplantation over the last decade: Children experienced increased wait time and death. *Am J Transplant* 2019; **19**: 3114-3123 [PMID: 31152483 DOI: 10.1111/ajt.15481]
 - 10 **Chul Yoon K**, Song S, Jwa EK, Lee S, Man Kim J, Kim OK, Kyun Hong S, Yi NJ, Lee KW, Soo Kim M, Hwang S, Suh KS, Lee SK. Survival Outcomes in Split Compared With Whole Liver Transplantation. *Liver Transpl* 2018; **24**: 1411-1424 [PMID: 29747216 DOI: 10.1002/lt.25196]
 - 11 **Kiuchi T**, Kasahara M, Uryuhara K, Inomata Y, Uemoto S, Asonuma K, Egawa H, Fujita S, Hayashi M, Tanaka K. Impact of graft size mismatching on graft prognosis in liver transplantation from living donors. *Transplantation* 1999; **67**: 321-327 [PMID: 10075602 DOI: 10.1097/00007890-199901270-00024]
 - 12 **Tanaka A**, Tanaka K, Tokuka A, Kitai T, Shinohara H, Hatano E, Sato S, Inomoto T, Takada Y, Higashiyama H, Nakamura Y, Yamamoto Y, Egawa H, Uemoto S, Ikai I, Ozaki N, Inomata Y, Yamaoka Y. Graft size-matching in living related partial liver transplantation in relation to tissue oxygenation and metabolic capacity. *Transpl Int* 1996; **9**: 15-22 [PMID: 8748406 DOI: 10.1007/BF00336807]
 - 13 **Younossi ZM**, Koenig AB, Abdelatif D, Fazel Y, Henry L, Wymer M. Global epidemiology of nonalcoholic fatty liver disease-Meta-analytic assessment of prevalence, incidence, and outcomes. *Hepatology* 2016; **64**: 73-84 [PMID: 26707365 DOI: 10.1002/hep.28431]
 - 14 **Gao X**, Fan JG; Study Group of Liver and Metabolism, Chinese Society of Endocrinology. Diagnosis and management of non-alcoholic fatty liver disease and related metabolic disorders: consensus statement from the Study Group of Liver and Metabolism, Chinese Society of Endocrinology. *J Diabetes* 2013; **5**: 406-415 [PMID: 23560695 DOI: 10.1111/1753-0407.12056]
 - 15 **Spitzer AL**, Lao OB, Dick AA, Bakthavatsalam R, Halldorson JB, Yeh MM, Upton MP, Reyes JD, Perkins JD. The biopsied donor liver: incorporating macrosteatosis into high-risk donor assessment. *Liver Transpl* 2010; **16**: 874-884 [PMID: 20583086 DOI: 10.1002/lt.22085]
 - 16 **Kromrey ML**, Ittermann T, vWahsen C, Plodeck V, Seppelt D, Hoffmann RT, Heiss P, Kühn JP. Reference values of liver volume in Caucasian population and factors influencing liver size. *Eur J Radiol* 2018; **106**: 32-37 [PMID: 30150048 DOI: 10.1016/j.ejrad.2018.07.005]
 - 17 **Bian H**, Hakkarainen A, Zhou Y, Lundbom N, Olkkonen VM, Yki-Järvinen H. Impact of non-alcoholic fatty liver disease on liver volume in humans. *Hepatol Res* 2015; **45**: 210-219 [PMID: 24698021 DOI: 10.1111/hepr.12338]
 - 18 **Yoshizumi T**, Gondolesi GE, Bodian CA, Jeon H, Schwartz ME, Fishbein TM, Miller CM, Emre S. A simple new formula to assess liver weight. *Transplant Proc* 2003; **35**: 1415-1420 [PMID: 12826175 DOI: 10.1016/s0041-1345(03)00482-2]
 - 19 **Saadeh S**, Younossi ZM, Remer EM, Gramlich T, Ong JP, Hurley M, Mullen KD, Cooper JN, Sheridan MJ. The utility of radiological imaging in nonalcoholic fatty liver disease. *Gastroenterology* 2002; **123**: 745-750 [PMID: 12198701 DOI: 10.1053/gast.2002.35354]
 - 20 **Kleiner DE**, Brunt EM, Van Natta M, Behling C, Contos MJ, Cummings OW, Ferrell LD, Liu YC, Torbenson MS, Unalp-Arida A, Yeh M, McCullough AJ, Sanyal AJ; Nonalcoholic Steatohepatitis Clinical Research Network. Design and validation of a histological scoring system for nonalcoholic fatty liver disease. *Hepatology* 2005; **41**: 1313-1321 [PMID: 15915461 DOI: 10.1002/hep.20701]
 - 21 **Bedossa P**; FLIP Pathology Consortium. Utility and appropriateness of the fatty liver inhibition of progression (FLIP) algorithm and steatosis, activity, and fibrosis (SAF) score in the evaluation of biopsies of nonalcoholic fatty liver disease. *Hepatology* 2014; **60**: 565-575 [PMID: 24753132 DOI: 10.1002/hep.27071]

- 10.1002/hep.27173]
- 22 **Batts KP**, Ludwig J. Chronic hepatitis. An update on terminology and reporting. *Am J Surg Pathol* 1995; **19**: 1409-1417 [PMID: 7503362 DOI: 10.1097/00000478-199512000-00007]
 - 23 **Fu-Gui L**, Lu-Nan Y, Bo L, Yong Z, Tian-Fu W, Ming-Qing X, Wen-Tao W, Zhe-Yu C. Estimation of standard liver volume in Chinese adult living donors. *Transplant Proc* 2009; **41**: 4052-4056 [PMID: 20005340 DOI: 10.1016/j.transproceed.2009.08.079]
 - 24 **Van Thiel DH**, Hagler NG, Schade RR, Skolnick ML, Heyl AP, Rosenblum E, Gavalier JS, Penkrot RJ. In vivo hepatic volume determination using sonography and computed tomography. Validation and a comparison of the two techniques. *Gastroenterology* 1985; **88**: 1812-1817 [PMID: 3888769 DOI: 10.1016/0016-5085(85)90005-8]
 - 25 **Yu HC**, You H, Lee H, Jin ZW, Moon JI, Cho BH. Estimation of standard liver volume for liver transplantation in the Korean population. *Liver Transpl* 2004; **10**: 779-783 [PMID: 15162473 DOI: 10.1002/Lt.20188]
 - 26 **Heinemann A**, Wischhusen F, Püschel K, Rogiers X. Standard liver volume in the Caucasian population. *Liver Transpl Surg* 1999; **5**: 366-368 [PMID: 10477836 DOI: 10.1002/Lt.500050516]
 - 27 **Du Bois D**, Du Bois EF. A formula to estimate the approximate surface area if height and weight be known. 1916. *Nutrition* 1989; **5**: 303-311; discussion 312 [PMID: 2520314]
 - 28 **Lin XZ**, Sun YN, Liu YH, Sheu BS, Cheng BN, Chen CY, Tsai HM, Shen CL. Liver volume in patients with or without chronic liver diseases. *Hepatogastroenterology* 1998; **45**: 1069-1074 [PMID: 9756008]
 - 29 **DeLand FH**, North WA. Relationship between liver size and body size. *Radiology* 1968; **91**: 1195-1198 [PMID: 5699624 DOI: 10.1148/91.6.1195]
 - 30 **Choukèr A**, Martignoni A, Dugas M, Eisenmenger W, Schauer R, Kaufmann I, Schelling G, Løhe F, Jauch KW, Peter K, Thiel M. Estimation of liver size for liver transplantation: the impact of age and gender. *Liver Transpl* 2004; **10**: 678-685 [PMID: 15108261 DOI: 10.1002/Lt.20113]
 - 31 **Vauthey JN**, Abdalla EK, Doherty DA, Gertsch P, Fenstermacher MJ, Loyer EM, Lerut J, Materne R, Wang X, Encarnacion A, Herron D, Mathey C, Ferrari G, Charnsangavej C, Do KA, Denys A. Body surface area and body weight predict total liver volume in Western adults. *Liver Transpl* 2002; **8**: 233-240 [PMID: 11910568 DOI: 10.1053/jlts.2002.31654]
 - 32 **Hashimoto T**, Sugawara Y, Tamura S, Hasegawa K, Kishi Y, Kokudo N, Makuuchi M. Estimation of standard liver volume in Japanese living liver donors. *J Gastroenterol Hepatol* 2006; **21**: 1710-1713 [PMID: 16984594 DOI: 10.1111/j.1440-1746.2006.04433.x]
 - 33 **Chan SC**, Liu CL, Lo CM, Lam BK, Lee EW, Wong Y, Fan ST. Estimating liver weight of adults by body weight and gender. *World J Gastroenterol* 2006; **12**: 2217-2222 [PMID: 16610024 DOI: 10.3748/wjg.v12.i4.2217]
 - 34 **Yuan D**, Lu T, Wei YG, Li B, Yan LN, Zeng Y, Wen TF, Zhao JC. Estimation of standard liver volume for liver transplantation in the Chinese population. *Transplant Proc* 2008; **40**: 3536-3540 [PMID: 19100432 DOI: 10.1016/j.transproceed.2008.07.135]
 - 35 **Poovathumkadavil A**, Leung KF, Al Ghamdi HM, Othman Iel H, Meshikhes AW. Standard formula for liver volume in Middle Eastern Arabic adults. *Transplant Proc* 2010; **42**: 3600-3605 [PMID: 21094823 DOI: 10.1016/j.transproceed.2010.07.098]
 - 36 **Um EH**, Hwang S, Song GW, Jung DH, Ahn CS, Kim KH, Moon DB, Park GC, Lee SG. Calculation of standard liver volume in Korean adults with analysis of confounding variables. *Korean J Hepatobiliary Pancreat Surg* 2015; **19**: 133-138 [PMID: 26693231 DOI: 10.14701/kjhbps.2015.19.4.133]
 - 37 **Mosteller RD**. Simplified calculation of body-surface area. *N Engl J Med* 1987; **317**: 1098 [PMID: 3657876 DOI: 10.1056/NEJM198710223171717]
 - 38 **Midorikawa T**, Kondo M, Beekley MD, Koizumi K, Abe T. High REE in Sumo wrestlers attributed to large organ-tissue mass. *Med Sci Sports Exerc* 2007; **39**: 688-693 [PMID: 17414807 DOI: 10.1249/mss.0b013e31802f58f6]
 - 39 **Abe T**, Kearns CF, Fukunaga T. Sex differences in whole body skeletal muscle mass measured by magnetic resonance imaging and its distribution in young Japanese adults. *Br J Sports Med* 2003; **37**: 436-440 [PMID: 14514537 DOI: 10.1136/bjism.37.5.436]
 - 40 **Feng LM**, Wang PQ, Yu H, Chen RT, Wang J, Sheng X, Yuan ZL, Shi PM, Xie WF, Zeng X. New formula for predicting standard liver volume in Chinese adults. *World J Gastroenterol* 2017; **23**: 4968-4977 [PMID: 28785151 DOI: 10.3748/wjg.v23.i27.4968]
 - 41 **Zhou F**, Zhou J, Wang W, Zhang XJ, Ji YX, Zhang P, She ZG, Zhu L, Cai J, Li H. Unexpected Rapid Increase in the Burden of NAFLD in China From 2008 to 2018: A Systematic Review and Meta-Analysis. *Hepatology* 2019; **70**: 1119-1133 [PMID: 31070259 DOI: 10.1002/hep.30702]
 - 42 **Loomba R**, Sanyal AJ. The global NAFLD epidemic. *Nat Rev Gastroenterol Hepatol* 2013; **10**: 686-690 [PMID: 24042449 DOI: 10.1038/nrgastro.2013.171]
 - 43 **Li J**, Zou B, Yeo YH, Feng Y, Xie X, Lee DH, Fujii H, Wu Y, Kam LY, Ji F, Li X, Chien N, Wei M, Ogawa E, Zhao C, Wu X, Stave CD, Henry L, Barnett S, Takahashi H, Furusyo N, Eguchi Y, Hsu YC, Lee TY, Ren W, Qin C, Jun DW, Toyoda H, Wong VW, Cheung R, Zhu Q, Nguyen MH. Prevalence, incidence, and outcome of non-alcoholic fatty liver disease in Asia, 1999-2019: a systematic review and meta-analysis. *Lancet Gastroenterol Hepatol* 2019; **4**: 389-398 [PMID: 30902670 DOI: 10.1016/S2468-1253(19)30039-1]
 - 44 **McCormack L**, Dutkowski P, El-Badry AM, Clavien PA. Liver transplantation using fatty livers: always feasible? *J Hepatol* 2011; **54**: 1055-1062 [PMID: 21145846 DOI: 10.1016/j.jhep.2010.11.004]

- 45 **Wong TC**, Fung JY, Chok KS, Cheung TT, Chan AC, Sharr WW, Dai WC, Chan SC, Lo CM. Excellent outcomes of liver transplantation using severely steatotic grafts from brain-dead donors. *Liver Transpl* 2016; **22**: 226-236 [PMID: 26359934 DOI: 10.1002/lt.24335]
- 46 **Chen TY**, Chen CL, Tsang LL, Huang TL, Wang CC, Concejero AM, Lu CH, Cheng YF. Correlation between hepatic steatosis, hepatic volume, and spleen volume in live liver donors. *Transplant Proc* 2008; **40**: 2481-2483 [PMID: 18929772 DOI: 10.1016/j.transproceed.2008.08.045]
- 47 **Busetto L**, Tregnaghi A, De Marchi F, Segato G, Foletto M, Sergi G, Favretti F, Lise M, Enzi G. Liver volume and visceral obesity in women with hepatic steatosis undergoing gastric banding. *Obes Res* 2002; **10**: 408-411 [PMID: 12006641 DOI: 10.1038/oby.2002.56]



Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-3991568
E-mail: bpgoffice@wjgnet.com
Help Desk: <https://www.f6publishing.com/helpdesk>
<https://www.wjgnet.com>

