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Prediction of portal pressure from intraoperative ultrasonography

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ABSTRACT

Background: Portal hypertension is a major risk factor for hepatic failure or bleeding in patients who have undergone hepatectomy, but it cannot be measured indirectly. We attempted to evaluate the intraoperative ultrasonography parameters that correlate with portal pressure (PP) in patients undergoing hepatectomy.

Methods: We examined 30 patients in whom PP was directly measured during surgery. The background liver conditions included chronic viral liver disease in seven patients, chemotherapy-associated steatohepatitis in four patients, fatty liver in one patient, hepatolithiasis in one patient, obstructive jaundice in one patient, and a normal liver in 16 patients. A multivariate logistic analysis and linear regression analysis were conducted to develop a predictive formula for PP.

Results: The mean PP was 10.4 ± 4.1 mm Hg. The PP tended to be increased in patients with chronic viral hepatitis. A univariate analysis identified the association of the six following parameters with PP: the platelet count and the maximum (max), minimum (min), end-diastolic, peak-systolic, and mean velocity in the portal vein (PV) flow. Using multiple linear regression analysis, the predictive formula using the PV max and min was as follows: Y (estimated PP) = 18.235−0.120 × (PV max.[m/s])−0.364 × (PV min). The calculated PP (10.44 ± 2.61 mm Hg) was nearly the same as the actual PP (10.43 ± 4.07 mm Hg). However, there was no significant relationship between the calculated PP and the intraoperative blood loss and post hepatectomy morbidity.

Conclusions: This formula, which uses ultrasonographic Doppler flow parameters, appears to be useful for predicting PP.

1. Introduction

The operative morbidity and mortality rates in patients who undergo hepatic resections have decreased in recent years due to improvements in both the preoperative evaluation of the liver's functional reserve and in perioperative management [1]. Portal hypertension remains a lethal operative risk in patients with liver dysfunction, such as cirrhosis, and should be carefully evaluated [2]. However, portal pressure (PP) can be measured directly by the insertion of a catheter via a trans-hepatic or trans-intestinal venous approach [3,4]. This approach is an invasive and complicated measure, requiring either puncture of the liver or laparotomy. PP cannot currently be measured using indirect tests. In cases where evaluation is

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performed for pulmonary hypertension, the gradient flow velocity or the volume of the cardiac tricuspid valve on ultrasonography can be used to predict the pulmonary arterial pressure [5]. In addition, the gradient of the hepatic venous-PP can be evaluated by various means [6–8]. However, indirectly evaluating PP itself remains difficult. Some investigators have attempted to identify the factors associated with portal hypertension [9–11], but clear predictors of PP have yet to be clarified.

Ultrasonography can be easily performed before or during surgery and can be used to measure the velocity, resistant index, and so forth. [12]. Intraoperative ultrasonography (IOUS) is an essential tool to determine tumor locations, surgical margins, and adjacent vascular involvement. The accuracy of determining the flow Doppler by IOUS is high (4, 5). The flow Doppler's ultrasonographic parameters reflect the dynamics of the hepatic inflow and outflow, which may be associated with both the PP and the background liver status [13,14]. To the best of our knowledge, no indirect prediction of PP using ultrasonographic parameters has yet been reported. The analysis of PP using a predictive formula would be useful for evaluating operative risks and reducing portal hypertension-related hepatic complications in patients who undergo hepatectomy. We therefore attempted to examine the IOUS parameters that correlate with PP in patients for whom PP could be measured directly during operation. We hypothesized that IOUS Doppler is a useful tool for evaluating hepatic vascularization and for accurately evaluating the correlation between the hepatic flow and the PP during surgery, which is important for evaluating portal hypertension.

The aim of the present preliminary study was to clarify aspects of IOUS that may predict PP. For this purpose, as a preliminary study, the present study examined the relationships between the PP and ultrasonographic parameters in 30 patients with various liver diseases in whom PP was directly measured to predict true PP.

2. Methods

2.1. Patients

Subjects comprised 30 patients (21 men and nine women) with or without liver disease who underwent hepatectomies in the Department of Surgical Oncology at Nagasaki University Graduate School of Biomedical Sciences between February 2013 and January 2014. The 32 patients were consecutively entered for the present study; however, two patients (metastatic liver carcinoma and hepatocellular carcinoma) could not technically undergo measuring the direct PP because of the post-colectomy and post-cholecystectomy adhesions, respectively. The mean (± standard deviation) age was 66 ± 13 y (range, 30–85 y). The liver diseases warranting hepatic resection included hepatocellular carcinomas in 14 patients, metastatic liver carcinomas in eight patients, intrahepatic cholangiocarcinomas in three patients, and bile duct carcinomas in five patients. The background liver condition was chronic viral liver disease in seven patients (including cirrhosis in two), chemotherapy-associated steatohepatitis in four patients, fatty liver in one patient, hepatolithiasis in one patient, obstructive jaundice in one patient, and normal livers in 16 patients.

In our hospital, the volume of the liver to be resected is estimated before surgery based on the results of the indocyanine green retention rate at 15 min (ICGR15) using Takasaki formula [15]. The liver volume, excluding the tumor, is measured by computed tomography volumetry [16]. Since 2004, we have modified our criteria and have used ^{99m}Tc-GSA scintigraphy and the associated functional hepatic volumetry, serum hepatic artery (HA) level and prothrombin activity based on ICGR15 testing to determine the extent of a hepatectomy [17]. In this cohort, we performed limited resections in five patients, a segmentectomy or sectionectomy in 12 patients, a lobectomy or more extended lobectomy in 10 patients, and a pancreaticoduodenectomy in three patients. The study design was approved by the ethics review board at our university hospital, and informed consent for the data collection was obtained from each patient before participation.

2.2. Evaluated parameters

The clinical data, results of conventional liver function tests, and surgical data were analyzed. The indocyanine green was injected intravenously at a dose of 0.5 mg/kg body weight, and the 15-min retention rate was measured using a photopiece applied to the fingertip (RK-1000; Sumitomo Electric, Tokyo, Japan) without blood sampling [17,18]. Patients received 3 mg (185 MBq) of ^{99m}Tc-GSA (Nihon Medi-Physics, Nishinomiya, Japan) as a bolus dose into the antecubital vein. The clearance index of ^{99m}Tc-GSA (HH15) and the hepatic uptake ratio of ^{99m}Tc-GSA (LHL15; the count ratio in the liver compared with the sum of the count ratios for the heart and liver at 15 min after the injection of 99mTc-GSA) were calculated after the injection of ^{99m}Tc-GSA [18]. The HA was assayed using the sandwich binding protein assay (SRL, Tokyo, Japan). The normal value of the serum HA as determined by the laboratory data of SRL is <50 ng/mL [13,17,18]. Analysis of the histologic fibrosis (staging) and necroinflammatory responses (grading) were followed by calculating the Knodell score. [19].

2.3. Direct measurement of PP and the IOUS Doppler

A 24-Fr venous catheter was inserted intraoperatively via the portal trunk, and the tip of the catheter was placed at the major portal trunk. Then, the catheter was connected with the anesthesia pressure monitoring system, and the PP was directly measured. The IOUS examination was performed using an XarioTM XG (Toshiba Medical Systems, Tokyo, Japan) a micro-convex probe (PVT-375BT, 3.5 MHz; Toshiba), and an interoperative probe (PLT-705BTH, 7.5 MHz). All IOUS were performed by surgeons to help with determining the indication for hepatectomy. First, we examined the two-dimensional images of the tumor and its location and also the Color Doppler Images of the tumor vasculature. For tumors located on the liver's surface, the liver was covered with warm saline to reduce the air-gap between the probe and the liver's surface. We separately scanned the hepatic flow in the portal vein (PV) and in the HA in the anterior segment of the liver and the middle hepatic vein before the hepatic