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Correlation between liver elasticity by ultrasound elastography and liver functional reserve

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Abstract

No worldwide consensus on the assessment tool for liver functional reserve is currently available. The aim of this study was to evaluate correlation between liver elasticity of both hepatic lobes and liver functional reserve tests. This prospective observational study comprised 40 patients scheduled for hepatectomy. Liver elasticity was assessed by Virtual Touch™ Quantification (VTQ). The mean VTQ value for the right and left lobes was defined as the mVTQ. Liver functional reserve was measured by technetium-^{99m}-diethylenetriaminepentaacetic acid-galactosyl-human serum albumin (^{99m}Tc-GSA) scintigraphy as LHL15 and HH15, and indocyanine green (ICG) excretion test as ICG-R15 and ICG-K. All examinations were measured after biliary decompression confirmed serum total bilirubin level $\leq 2\text{mg/dL}$. mVTQ values were moderately correlated with LHL15 ($r=-0.42$, $P<0.01$), HH15 ($r=0.48$, $P<0.01$), ICG-R15 values ($r=0.53$, $P<0.01$), and ICG-K ($r=-0.61$, $P<0.01$). In conclusion, the liver elasticity by VTQ would be a useful predictor for liver functional reserve in patients scheduled for hepatectomy.

Keywords: Ultrasound elastography, Liver elasticity, Virtual Touch™ Quantification, Liver functional reserve, Technetium-^{99m}-diethylenetriaminepentaacetic acid-galactosyl-

52 human serum albumin, Indocyanine green excretion test

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Introduction

Bile duct cancer (BDC) and hepatocellular carcinoma (HCC) are the most common malignant tumors of the hepatobiliary system. Hepatectomy is the most effective method for the radical cure of hilar BDC (HBDC), intrahepatic BDC (IHBDC), and HCC (Nimura et al 1998; Miyazaki et al 2007), however, excessive hepatectomy has a high risk of liver failure in BDC and HCC patients (Breitenstein et al 2010; Lock et al 2009). To reduce post-hepatectomy morbidity and mortality, preoperative assessment of liver functional reserve is important (Mizumoto et al 1979). Technetium-^{99m}-diethylenetriaminepentaacetic acid-galactosyl-human serum albumin (^{99m}Tc-GSA) scintigraphy (Kwon et al 1995), the indocyanine green (ICG) excretion test (Lau et al 1997), the Child-Pugh (CP) classification (Testa et al 1999), and liver damage class (Hasegawa et al 2013) are the main modalities or tools to assess liver functional reserve in clinical practice. ^{99m}Tc-GSA is a receptor-binding ligand that specifically binds to the asialoglycoprotein receptor (ASGPR) on hepatocytes, and the liver is the only uptake site for ^{99m}Tc-GSA. The number of ASGPRs reflects the number of functioning hepatocytes; thus, ^{99m}Tc-GSA scintigraphy allows a direct estimation of functioning hepatocytes and can be used to evaluate the liver functional reserve (Kwon et al 1995; Hwang et al 1999).

In addition, the ICG excretion test is widely used to determine liver functional reserve in Asia (Lau et al 1997). After intravenous administration, ICG binds completely to albumin and beta-lipoprotein and is exclusively removed by the liver and excreted in its unchanged form in bile without any entero-hepatic circulation (Caesar et al 1961). ⁹⁹mTc-GSA scintigraphy is expensive and exposes patients to additional radiation, while the ICG excretion test requires patients at rest and accurate timing and dosages. As these methods have different limitations and accuracies, there has not been a worldwide consensus on a standard assessment of liver functional reserve.

Recently, ultrasound-based methods have been developed to quantify liver elasticity for the assessment of liver fibrosis and cirrhosis. Of these, the best-known method is imaging Virtual TouchTM Quantification (VTQ) with acoustic radiation force impulse imaging (Sporea et al 2013; Potthoff et al 2013; Friedrich-Rust et al 2012; Bota et al 2014; Chen et al 2012; Litchfield et al 2014; Armstrong et al 2012). VTQ measures the velocity of a transverse shear wave generated by a short-duration acoustic push pulse with values expressed in units of velocity (meter per second, m/s) (Nightingale et al 2003). VTQ can be used to evaluate liver conditions with a relatively wide range of depths. Some studies have reported that liver elasticity is positively correlated with ICG-R15 and Child-

Pugh classification in patients with liver fibrosis or cirrhosis (Fung et al 2013; Sun et al 2015). However, correlation between liver elasticity of both hepatic lobes and ⁹⁹mTc-GSA scintigraphy is unclear.

The aim of this prospective study was to evaluate correlation between liver elasticity of both hepatic lobes, VTQ and a liver functional reserve test, ⁹⁹mTc-GSA scintigraphy in patients with hepatobiliary diseases.

Materials and Methods

Study design

This was a prospective observational cohort study conducted at the Hokkaido University Hospital, a tertiary referral center. Between October 2016 and January 2018, patients with a primary disease of the hepatobiliary system scheduled for hepatectomy were examined at our hospital and enrolled. Because preoperative chemotherapy might affect the liver elasticity, patients such as liver metastases from colorectal cancer were not included in this study. The exclusion criteria were 1) patients who had diffuse liver tumors, 2) acute cholangitis, and 3) obstructive jaundice and serum total bilirubin (T-Bil) level >2 mg/dL after biliary drainage. The study protocol conforms to the ethical guidelines of the 1975

Declaration of Helsinki (6th revision, 2008) as reflected in a priori approval by the institution's human research committee. The study was approved by the Institutional Review Board of the Hokkaido University Hospital (016–0188). All patients provided written informed consent to participate in the study.

Measurements of liver elasticity

A single experienced operator (R.S.) measured liver elasticity by VTQ, using the ACUSON S2000[®] instrument (Siemens AG, Erlangen, Germany) with a 4CI ultrasound probe (1.0–4.5 MHz). VTQ measurements were completed during the same session for all patients. Values measured by VTQ were expressed in m/s (Fig. 1). The best cut-off values of VTQ to predict fibrosis ($F \geq 1$), significant fibrosis ($F \geq 2$), severe fibrosis ($F \geq 3$) and cirrhosis were 1.19 m/s, 1.36 m/s, 1.47 m/s and 1.69 m/s, respectively (Sporea et al 2012). VTQ measurements were performed under breath hold according to the World Federation for Ultrasound in Medicine and Biology guideline. VTQ was measured at two sites: one at the right lobe of the liver (VTQ-R) accessed through the hypochondrium space, and the other at the left lobe of the liver (VTQ-L) accessed through the overlying intercostal space at a depth of 2–4 cm as described previously (Kubo et al 2016). The

mean VTQ-R and VTQ-L values were defined as an mVTQ value. If either VTQ-R or VTQ-L value was not measurable due to a non-drainage area or because the liver parenchyma was occupied by large tumors, a measurable VTQ-R or VTQ-L value alone was defined as the mVTQ value. Liver elasticity was measured in patients with obstructive jaundice after biliary drainage and serum T-Bil level ≤ 2 mg/dL was confirmed.

The results were considered reliable when a success rate of measurement of at least 60% in 10 acquisition trials (i.e., ratio between validated and total measurements) was obtained. In addition, the median value was considered representative of the VTQ measurement only if the interquartile range (IQR) of all validated measurements was within 30% of the median value.

Measurements of ^{99}mTc -GSA scintigraphy

After a bolus intravenous injection of 185 MBq of ^{99}mTc -GSA (Nihon Medi-Physics, Nishinomiya, Japan), dynamic scanning was performed with the patient in a supine position, using a large-field view gamma camera (Mochida SIEMENS Medical Systems) in an anterior view equipped with a low-energy high-resolution collimator. The dynamic planar images were obtained for 30 minutes. The hepatic uptake ratio of ^{99}mTc -GSA

(LHL15) was calculated after injection of ^{99}mTc -GSA as the liver activity at 15 minutes (L15) divided by heart plus liver activity at 15 minutes (H15+L15). The blood clearance ratio of ^{99}mTc -GSA (HH15) was calculated as the heart activity at 15 minutes (H15) divided by heart activity at 3 minutes (H3) after injection of ^{99}mTc -GSA. The interval between the VTQ and ^{99}mTc -GSA measurements was within two weeks.

A previous report showed that there was a small distribution of LHL15 in patients with almost normal liver function or slight liver damage (Kawamura et al 2008). In this study, it was expected that the liver functional reserve of many participants would be good because they would be potential candidates for hepatectomy. Thus, we chose to use LHL15 as an index of the primary outcome.

Measurements of the ICG excretion test

The ICG excretion test was performed after the patient had fasted for 6 hours. ICG was intravenously administered at a dose of 0.5 mg/kg. Blood ICG concentrations were monitored before and 5, 10, and 15 minutes after administration and the ICG retention value at 15 minutes (ICG-R15) was calculated. ICG-R15 is less than 10% in normal individuals, and this value was used for stratification of patients in the present study

(Watanabe and Kumon 1999). The indocyanine green elimination rate constant (ICG-K) was calculated automatically according to the time course of blood ICG concentrations as possible (Hsieh et al 2004).

Serum liver function and blood coagulation tests

Blood samples were obtained from all patients before enrollment. If patients had obstructive jaundice, blood samples were obtained after biliary drainage and T-Bil levels of ≤ 2 mg/dL were confirmed. The following serum liver function and blood coagulation tests were performed: aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), γ -glutamyltranspeptidase (γ -GTP), T-Bil, albumin, and prothrombin time (PT).

Child-Pugh score and liver damage severity

Child-Pugh (CP) scores and liver damage severities were calculated and ranked based on patient's blood samples and physical condition before enrollment as previously reported (Testa et al 1999; Hasegawa et al 2013).

Diagnosis of chronic liver diseases

Chronic hepatitis B was diagnosed by the presence of serum hepatitis B surface antigen, core antibody, hepatitis B virus DNA, and abnormal liver function tests for more than 6 months. Chronic hepatitis C was diagnosed by the presence of serum anti-hepatitis C virus antibodies, hepatitis C virus RNA, and abnormal liver function tests for more than 6 months. Diagnosis of nonalcoholic steatohepatitis was confirmed by a liver biopsy or surgically resected specimen in patients with abnormal liver function tests / bright liver echoes at ultrasonography without other causes of liver disease (Gaia et al 2011).

Outcome measures

The primary outcome of the present study was the correlation coefficient between mVTQ and LHL15 values. The secondary outcomes were the correlation coefficients for mVTQ and HH15 values, mVTQ and ICG-R15 values, mVTQ and ICG-K, and VTQ in each liver lobe and LHL15, HH15, ICG-R15, and ICG-K values.

Sample size

One previous report (Kubo et al 2016) indicated the correlation between VTQ values and serum markers of liver fibrosis ($r=0.35-0.67$), and another report (Sun et al 2015) revealed the moderate correlation between VTQ-R and ICG-R15 ($r=0.62$). Although there has been no report regarding correlation between mVTQ and LHL15 values, on the basis of the two previous reports, we assumed the moderate correlation between mVTQ and LHL15 values (correlation coefficients = -0.5) in this study. We also set 90% as a power and 0.025 as the α error (one-sided). Based on this assumption, the sample size calculated to be required for the study was determined to be 37. Assuming there would be some dropouts of enrolled patients, a total of 40 enrolled patients was set as a final sample size.

Statistical analysis

Statistical analyses were performed using GraphPad Prism software 7.0 (GraphPad Software Inc., San Diego, CA). Results are shown as means (SD) for quantitative variables, medians (range) for nonparametric variables, and percentages for categorical variables. Values of VTQ in each liver lobe among tumor site were compared using one-way ANOVA. Correlation coefficients were calculated using the Pearson's product-

moment correlation coefficient. The classification of correlation coefficient (r) was as follows: almost none, $|r| < 0.2$; mild, $|r| = 0.2-0.4$; moderate, $|r| = 0.4-0.7$, and strong, $|r| \geq 0.7$. Differences were considered statistically significant at a P -value of <0.05 .

Result

Baseline characteristics

The characteristics of the patients of our study are presented in Table 1. Thirty-two males and 8 females with a median age of 69 (range 43–84) years were enrolled. The median of body mass index was 23.4 kg/m^2 (range 16.8–31.7). The baseline diseases were HBDC in 15 patients, HCC in 9 patients, IHBDC in 8 patients, distal BDC in 2 patients, gallbladder cancer in 2 patients, intrahepatic biliary stone in 2 patients, hemangioma in 1 patient, and liver sarcomatoid carcinoma in 1 patient. The etiologies of HCC were chronic hepatitis C in 5 patients, chronic hepatitis B in 2 patients, alcoholic hepatopathy in 1 patient, and nonalcoholic steatohepatitis in 1 patient. No patient had portal hypertension. Results of serum liver function tests of all patients were shown in Table 1. The median of the intervals between a serum liver function test and

VTQ measurement was 4.5 days (range 0–24). The CP classifications were A in 39

patients and B in 1 patient, and no patient was scored C.

VTQ, ⁹⁹mTc-GSA scintigraphy, ICG excretion test, CP score, and liver damage

severity results

All 40 patients underwent VTQ and ⁹⁹mTc-GSA scintigraphy. The median of the intervals between VTQ and ⁹⁹mTc-GSA scintigraphy was 1 day (range 0–13). VTQ-L values could not be accurately evaluated due to large non-drainage areas in 2 patients and liver parenchyma occupied large tumors in the liver in 2 patients. Of the remaining 36 patients, VTQ-L values could be accurately evaluated as described above. VTQ-R values were accurately evaluated in all 40 patients. Thirty-eight patients underwent ICG-R15, while it wasn't in 1 patient suspected of allergic to ICG, and in 1 patient with contracture of the one of the arm after cerebral infarction. Of these, ICG-K was calculated in 26 patients, while it wasn't in 14 patients at the discretion of the primary doctor. The median of the intervals between VTQ measurement and ICG excretion test was 1.5 days (range 0–75). With regard to liver damage severities, 34 patients were classified as liver damage A and 6 patients as liver damage B.

The values of mVTQ, VTQ-R, VTQ-L, LHL15, HH15, ICG-R15, and ICG-K

were shown in Table 2. All VTQ measurements met the criteria that the IQR of all

validated measurements was within 30% of the median value. The values of VTQ-

R/VTQ-L were not significantly different among the tumor site ($P > 0.05$) (Table 3).

Correlation analysis of VTQ and ^{99}mTc -GSA scintigraphy

The correlations between mVTQ and LHL15/HH15 values were verified. As shown in

Fig. 2A and 2B, moderate correlations between mVTQ and LHL15 values ($r = -0.42$, P

< 0.01) ($n = 40$) with a linear regression model of $\text{LHL15} = -0.0410 \times \text{mVTQ} + 0.988$

and between mVTQ and HH15 values ($r = 0.48$, $P < 0.01$) ($n = 40$) with a linear

regression model of $\text{HH15} = 0.101 \times \text{mVTQ} + 0.430$ were revealed. In addition, VTQ-R

/VTQ-L and LHL15 / HH15 values were tested as shown in Fig. 2C-F. The correlation

between VTQ-R and HH15 values was moderate ($r = 0.47$, $P < 0.01$) ($n = 40$). Mild

correlations were found between VTQ-R and LHL15 values ($r = -0.32$, $P = 0.02$) ($n =$

40), between VTQ-L and LHL15 values ($r = -0.39$, $P < 0.01$) ($n = 36$) and between

VTQ-L and HH15 values ($r = 0.37$, $P = 0.01$) ($n = 36$).

Using the regression formula and normal range of LHL15 (0.950 ± 0.015), the

normal cut-off value of mVTQ was calculated as 0.93 ± 0.36 (m/s).

Correlation analysis of the VTQ and ICG excretion tests

The correlations between mVTQ / VTQ-R / VTQ-L and ICG-R15/ICG-K values were

verified. As shown in Fig. 3A and 3B, moderate correlations between mVTQ and ICG-

R15 values ($r = 0.53$, $P < 0.01$) ($n = 38$) with a linear regression model of ICG-R15 =

$13.8 \times \text{mVTQ} - 4.77$, and between mVTQ and ICG-K values ($r = -0.61$, $P < 0.01$) ($n =$

26) with a linear regression model of ICG-K = $-0.0689 \times \text{mVTQ} + 0.242$ were

revealed. In addition, moderate correlations were found between VTQ-R and ICG-R15

values ($r = 0.41$, $P < 0.01$) ($n = 38$), between VTQ-R and ICG-K values ($r = -0.48$, $P <$

0.01) ($n = 26$), between VTQ-L and ICG-R15 values ($r = 0.50$, $P < 0.01$) ($N = 34$) and

between VTQ-L and ICG-K values ($r = -0.64$, $P < 0.01$) ($n = 23$) (Fig. 3C-F).

Using the regression formula and normal range of ICG-R15 (< 10), the normal

cut-off value of mVTQ was calculated as < 1.07 (m/s).

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Discussion

The present study demonstrated that VTQ values correlated with ^{99}mTc -GSA scintigraphy values, namely, that liver elasticity correlated with liver functional reserve. A previous report showed that LHL15 correlated with ICG-R15 in patients with liver damage A and that HH15 correlated with ICG-R15 in patients with moderate liver damage, defined as liver damage B (Kawamura et al 2008). In the present study, as expected, the correlation coefficient between the mVTQ and LHL15 values was essentially moderate as was the correlation coefficient between mVTQ and HH15 values.

A few studies have focused on ultrasound elastography as liver functional reserve. Fung et al. showed that the values of transient elastography (TE), which is also measured by ultrasound elastography, correlated well with ICG-R15 values (Fung et al 2013); however, correlation strength, namely, a correlation coefficient with TE and ICG-R15 values was not observed. Sun et al. showed that VTQ-R values were positively and moderately correlated with ICG-R15 ($r = 0.617$, $P < 0.01$) (Sun et al 2015), which is similar to our result. In their study, all patients had liver fibrosis or cirrhosis, while in the present study patients with normal or slight damaged liver

function were included. Thus, these previous studies and our data indicated that ultrasound elastography is a useful method to evaluate liver functional reserve regardless of severity of liver damage. LHL15 ($r=-0.42$) and HH15 ($r=0.48$) mean receptor and clearance index, respectively, while ICG tests (ICG-R, $r=0.53$; ICG-K, $r=-0.61$), clearance index of the liver. Thus, VTQ might be more strongly related to the clearance function.

The present study demonstrated that the VTQ value in each lobe also correlated with liver functional reserve. A previous study by Toshima et al. reported that VTQ-L value was higher than the VTQ-R value due to movements of some organs such as the heart, lungs, diaphragm, and stomach (Toshima et al 2011). Although only measurement of the VTQ-R would be sufficient to assess liver elasticity in patients with chronic liver injury such as viral hepatitis or alcoholic hepatopathy as described above (Fung et al 2013; Sun et al 2015), the measurement of the VTQ-L is occasionally necessary because the left lobe would be the future remnant liver lobe for many patients with HBDC in which the right hepatic artery is frequently involved in carcinoma. Our data indicate that measurement of the VTQ-L was also useful for evaluating liver functional reserve in patients with HBDC.

Previous studies have also shown that biliary obstruction was closely associated with changes in liver elasticity (Kubo et al 2016; Pfeifer et al 2014; Attia et al 2014). We hypothesized that a non-drainage area of the liver would influence liver elasticity; therefore, in the present study, we defined the new concept of mVTQ as an overall evaluation of the functional reserve of the liver. Consequently, the correlations using mVTQ values were better than those of VTQ-R or VTQ-L alone. This is the first report that the measurement of the VTQ-L and mVTQ is also useful for evaluation of liver functional reserve. For the clinical application of VTQ as a liver functional reserve test, we also need to consider the relationship between VTQ and patient prognosis after hepatectomy.

The value measured by ultrasound elastography including VTQ can be affected by various factors such as measurement site (Toshima et al 2011), obstructive jaundice (Kubo et al 2016; Pfeifer et al 2014; Attia et al 2014), food intake (Mederacke et al 2009; Goertz et al 2012) and acute liver damage (Arena et al 2008; Sagir et al 2008). Among them, liver fibrosis that is a result of chronic damage to the liver (Rockey and Bissell 2006); constitutes a major factor of VTQ as indicated by the previous report (Sporea et al 2012), therefore, VTQ can predict liver functional reserve. Their VTQ cut-

off value of fibrosis < F1 is almost compatible to our calculated normal VTQ cut-off values.

There are several limitations to the present study. First, this study was a single center study. Second, a non-blinded operator obtained measurements of liver elasticity. Third, the patients included in this study had already been selected as potential candidates for hepatectomy based on their normal clinical parameters. Therefore, a validation study with a large cohort is required to define the cut off value of VTQ for liver functional reserve. Finally, there is no comparison between values of VTQ and liver tissues.

Conclusion

Liver elasticity defined by ultrasound elastography correlated with liver functional reserve. Ultrasound elastography would be a useful predictor for liver functional reserve in patients scheduled for hepatectomy. Further studies are needed to evaluate ultrasound elastography as a modality for liver functional reserve.

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Figure captions list

Figure 1. Virtual Touch™ Quantification. Right lobe (upper) and left lobe (lower).

Figure 2. Correlation between Virtual Touch™ Quantification and technetium-^{99m}-diethylenetriaminepentaacetic acid-galactosyl-human serum albumin scintigraphy.

A. mVTQ and LHL15 ($r = -0.42$, $P < 0.01$).

B. mVTQ and HH15 ($r = 0.48$, $P < 0.01$).

C. VTQ-R and LHL15 ($r = -0.32$, $P = 0.02$).

D. VTQ-R and HH15 ($r = 0.47$, $P < 0.01$).

E. VTQ-L and LHL15 ($r = -0.39$, $P < 0.01$).

F. VTQ-L and HH15 ($r = 0.37$, $P = 0.01$).

VTQ, Virtual Touch™ Quantification; mVTQ, VTQ value for the right (VTQ-R) and left (VTQ-L) lobes, LHL15, hepatic uptake ratio of technetium-^{99m}-diethylenetriaminepentaacetic acid-galactosyl-human serum albumin (^{99m}Tc-GSA); HH15, blood clearance ratio of ^{99m}Tc-GSA.

Figure 3. Correlation between Virtual TouchTM Quantification measurement and

indocyanine green excretion test.

A. mVTQ and ICG-R15 ($r = 0.53$, $P < 0.01$).

B. mVTQ and ICG-K ($r = -0.61$, $P < 0.01$).

C. VTQ-R and ICG-R15 ($r = 0.41$, $P < 0.01$).

D. VTQ-R and ICG-K ($r = -0.48$, $P < 0.01$).

E. VTQ-L and ICG-R15 ($r = 0.50$, $P < 0.01$).

F. VTQ-L and ICG-K ($r = -0.64$, $P < 0.01$).

VTQ, Virtual TouchTM Quantification; mVTQ, VTQ value for the right (VTQ-R) and

left (VTQ-L) lobes; ICG-R15, indocyanine green retention value at 15 minutes; ICG-K,

indocyanine green elimination rate constant.

556 **Tables**

557 **Table 1.** Baseline characteristics

558	Sex (male : female), <i>n</i>	32 : 8
559	Age (median, range), year	69 (43–84)
560	Body mass index (median, range), kg/m ²	23.4 (16.8–31.7)
561	Final diagnosis, <i>n</i>	
562	Hilar BDC	15
563	Hepatocellular carcinoma	9
564	Intrahepatic BDC	8
565	Distal BDC	2
566	Gallbladder cancer	2
567	Intrahepatic biliary stone	2
568	Hemangioma	1
569	Liver sarcomatoid carcinoma	1
570	Etiology of hepatocellular carcinoma, <i>n</i>	
571	Chronic hepatitis C	5

572	Chronic hepatitis B	2
573	Alcoholic hepatopathy	1
574	Nonalcoholic steatohepatitis	1
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575	Aspartate aminotransferase, median (range), U/L	34 (13–211)
576	Alanine aminotransferase, median (range), U/L	39 (5–615)
577	Alkaline phosphatase, median (range), U/L	430 (91–2366)
578	γ -Glutamyltranspeptidase, median (range), U/L	162 (12–1659)
579	Total bilirubin, median (range), mg/dL	0.9 (0.3–2.0)
580	Albumin, median (range), g/dL	3.9 (2.1–4.8)
581	Prothrombin time, median (range), %	88.6 (60.8–125.8)
582	Child-Pugh classification, (A / B / C)	39 / 1 / 0
583	Liver damage severity (A / B / C)	34 / 6 / 0
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584	BDC, bile duct cancer	
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Table 2. Liver elasticity and liver functional reserve

	Cases	mean $\pm$ standard deviation
mVTQ (m/s)	40	1.35 $\pm$ 0.39
VTQ-R (m/s)	40	1.26 $\pm$ 0.42
VTQ-L (m/s)	36	1.47 $\pm$ 0.48
LHL15	40	0.932 $\pm$ 0.038
HH15	40	0.567 $\pm$ 0.082
ICG-R15 (%)	38	13.5 $\pm$ 9.0
ICG-K (min ⁻¹)	26	0.153 $\pm$ 0.041

VTQ, Virtual TouchTM Quantification; LHL15, hepatic uptake ratio of technetium-^{99m}-diethylenetriaminepentaacetic acid-galactosyl-human serum albumin (^{99m}Tc-GSA); HH15, blood clearance ratio of ^{99m}Tc-GSA; ICG-R15, indocyanine green retention value at 15 minutes; ICG-K, indocyanine green elimination rate constant

Table 3. Liver elasticity according to the tumor site

Tumor site	Right lobe	Left lobe	Both lobes / EBD	<i>P</i> value
	(<i>n</i> = 12)	(<i>n</i> = 12)	(<i>n</i> = 16)	
VTQ-R, mean (SD), m/s	1.44 ± 0.53	1.18 ± 0.27	1.19 ± 0.40	0.24
VTQ-L, mean (SD), m/s	1.65 ± 0.64	1.44 ± 0.46	1.35 ± 0.29	0.27

EBD, extrahepatic bile duct; VTQ, Virtual Touch™ Quantification

TIS: 0.5
TIB: 1.3
MI: 1.5

SIEMENS

4C1 / Abdomen

General

2D 100%

THI / H4.00 MHz

10 dB / DR 70

SC Off / DTCE M

Map D / ST 2

E 2 / P 2

T 11 / B 0

Liver Segment 5

Vs=1.29 m/s

Depth=2.8 cm

Cooling 0

Liver Segment 5: 1 valid Data

10fps

11cm

Fr317

TIS: 0.5
TIB: 1.2
MI: 1.5

SIEMENS

4C1 / Abdomen

General

2D 100%

THI / H4.00 MHz

10 dB / DR 70

SC Off / DTCE M

Map D / ST 2

E 2 / P 2

T 11 / B 0

Liver Segment 3

Vs=1.28 m/s

Depth=3.1 cm

Cooling 1

Liver Segment 3: 5 valid Data

10fps

11cm

Fr337