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Postoperative Liver Dysfunction and Portal Blood Flow Measured by Pulsed Doppler Ultrasonographic Flowmeter

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Abstract *Blood flow in the right anterior branch of portal vein was measured for perioperative period by pulsed Doppler ultrasonoqraphic flowmeter. Relation of blood flow in portal vein was studied to liver failure after surqery.* The patients were divided into *three qroups*; the early, the mid-term and late bilirubinemia according to the time when serum total bilirubin reached the peak after the abdominal surgery.

The portal blood flow was increased during the first few days in patients with the early and the mid-term bilirubinemia groups, in all of whom no serious complications including liver failure occurred during the course of their hospitalization. On the contrary, those with the late bilirubinemia group showed marked decrease in portal flow even in the early time after surgery, following which fatal liver damage occurred with high incidence.

It is suggested that perioperative evaluation of portal blood flow volume in the right anterior branch with pulsed Doppler flowmetry is useful to predict the subsequent occurrence of liver failure after abdominal surgery.

Key Words : Pulsed Doppler flowmetry, Portal hemodynamics, Liver dysfunction, Serum total bilirubin, Abdominal surgery

Introduction

Although there have been many studies on portal hemodynamics in various liver diseases (1), non-invasive daily observation of intrahepatic portal blood flow after surgery has rarely been reported, and little is known about the relationship of perioperative changes in portal flow *to* postoperative liver failure (2). *While there are many specific causes of liver dysfunction after surgery, the impairment of effective portal blood supply to liver may be one of the major causes.* In the present study, blood flow in the right anterior branch of the portal venous system in the patients with digestive disease was pursued before and after surgery with pulsed Doppler ultrasonography, and the relationship between changes in portal blood flow and liver dysfunction after surgery was investigated. Based on these results, the potential role of pulsed Doppler ultrasonography in the prediction of postoperative liver failure is discussed.

Patients and Methods

The study was carried out in 43 patients

Table1. Diagnosis and operative procedures in 43 patients

Diagnosis	Operative procedures	No. of the patiens
Esophageal ca.	total esophagectomy	7
Gastric ca.	total gastrectomy	3
	partial gastrectomy	7
	pancreatoduodenectomy	1
Colorectal ca.	hemicolectomy	1
	sigmoidectomy	3
	anterior resection	1
	Mile's operation	2
Pancreatic ca.	pancreatoduodenectomy	2
	IOR+IOH	2
Ca. of the papilla Vater	pancreatoduodenectomy	1
Chronic pancreatitis	pancreatoduodenectomy	2
Cholecystolithiasis	cholecystectomy	2
Esophageal varices	Hassab's operation+TAET	7
Miscellaneous	cholecystectomy	2

IOR: intraoperative radiation, IOH: intraoperative hyperthermia, TAET: transeabdominal esophageal transection, ca: carcinoma

without heart disease who *underwent in my clinic gastroenterological surgery* such as esophagectomy, gastrectomy, pancreatoduodenectomy, colectomy, cholecystectomy, Mile's operation, Hassab's operation and so forth (Table 1). Those who underwent liver surgery were all excluded from the present investigation. As an index of liver dysfunction, the serum total bilirubin values were measured repeatedly *in all patients,* who were classified into three groups according to the time when the postoperative serum bilirubin value showed the maximum. *Group A* was that bilirubin *reached* the maximum *in* the first three days after surgery. *Group B* showed the maximum *level of bilirubin* the period between the 4th and the 13th day after surgery. *Group C* showed the maximum after *the 14 days.*

Portal blood flow was measured in the right anterior branch of the portal vein *by* an ultrasonic convex scanner with a 3.5-MHz *transducer combined* with a pulsed Doppler apparatus (Alo*ka* SSD-650), on the day before surgery, and on the 1, 2, 3, 5 and 7th day after surgery. All measurements were performed after over-night fasting while the patients were lying in a supine position during breath-holding. The right anterior branch of the portal venous system was identified via the intercostal approach. Doppler signals were obtained from a 2 mm sample volume located at the center of the vessel within 1 cm distal from the bifurcation of the right posterior branch.

The equipment displayed an angle between the sonic beam and the longitudinal axis of the vessel lumen, and *the angle was kept* at less than 60 degrees for flow measurements. *Flow* velocity (V) was directly calculated from the Doppler spectral analysis, using the formula *(i) described* by Gill *(3),* where Fd is the Doppler frequency shift, *C is* the velocity of sound in the tissue (1530m/s), *Fr* is the emitted ultrasonic wave frequency, and θ is the angle between the sonic beam and the longitudinal axis of the vessel.

$$V = Fd.\ C/\ 2\ Fr.\ \cos\theta \quad \cdots\cdots\cdots\cdots\cdots (i)$$

The portal blood flow was measured consecutively three times at the same site in the right anterior portal branch. The mean of the three measurements was taken as the value

Table2. Preoperative clinical data in 43 patients

	Group A (n=31)	Group B (n=6)	Group C (n=6)
Age	59.4±2.3	62.0±2.7	58.3±4.3
Sex (No.of patients)			
male	20	6	3
female	11	0	3
Serum total bililubin level (mg/dl)	0.77±0.08[a]	0.65±0.08[b]	1.33±0.27[ab]
Serum GPT level (U)	18.4±5.5	18.3±2.5	42.8±24.4
Serum cholinesterase level (ΔpH)	0.74±0.04	0.78±0.17	0.53±0.11
Prothrombin time (%)	85.8±2.6	95.8±2.6	80.0±2.0
ICG R-15	9.00±1.66[c]	10.73±3.51	27.1±10.5[c]
Liver cirrhosis (No. of patients)	6	1	4

Superscript letters indicate significance of difference ($p<0.05$) between pairs of values with the same letter. ICGR-15: plasma retention rate of indocyanine green at 15min.

of the portal flow. The diameter of the vessel (D) was measured, using B-mode scan, at the same point at which the Doppler signals were obtained. *Nishihara et al. (4) assumed that the vessel had a circular cross section, the blood flow volume (BFV) was calculated by the formula (ii)*

$$BFV = 0.54.\ V.\ \pi.\ (D/2)^2.\ 60. \quad \cdots\cdots (ii)$$

The ratio of each postoperative portal flow volume to preoperative flow volume was measured and compared among the three groups.

Statistical analysis employed Scheff's F test with 95% confidence limits.

Results

Of 43 *patients,* 31 belonged to Group A and each six to Group B and C.

The clinical characteristics and preoperative laboratory values in each group are summarized in Table2. In all of the patients, the preoperative total bilirubin values were below 2.4mg/dl, but its mean value in Group C was significantly higher than that in Group A and B. Preoperative plasma retention rate of indocyanine green at 15 min. (ICG R-15) in Group C was significantly impaired than that in Group A. No significant difference was seen in preoperative GPT, cholinesterase and prothorombin time among the three groups. Liver cirrhosis was present in six (19.4%) of Group A, in one (16.7%) of Group B and in four (66.7%) of Group C.

The mean of the maximum bilirubin values (mean±S.E.) before surgery, in the first three days after surgery, during the period between the 4th and 13th postoperative day, and after the 14th postoperative day was in Group A 0.70±0.10, 1.52±0.18, 1.32±0.24, 0.82±0.11, respectively, that in Group B 0.65±0.08, 1.05±0.19, 2.00±0.46, 0.60±0.08, respectively, and that in Group C 1.33±0.27, 3.03±0.79, 6.75±2.73, 16.52±7.14 (Fig. 1). Those in Group C were significantly higher than those in Group A and *B. Liver* failure occurred in five (83.3%) of Group C, of which four died on the 30th, 31st., 33rd and 38 th postoperative days. On the other hand, no serious complications including liver failure occurred in all of Group A and B.

The changes of portal flow ratio (mean±S.E.) on Days 1, 2, 3, 5, and 7 after the surqery was in Group A 1.5±0.2, 1.4±0.1, 1.2±0.1, 1.1±0.1, respectively, that in Group B 2.1±0.5, 2.1±0.3, 2.6±0.4, 1.9±0.3, and 1.9±0.3, respectively, and that in Group C 0.7±0.3, 0.6±0.2, 0.6±0.1, 0.4±0.1, and 0.3±0.1, respectively (Fig. 2). In both Group A and B, especially in the latter, portal flow increased for the first few days after surgery and then gradually returned to the preoperative level. On the contrary, in Group C portal flow on the first few days after sur-

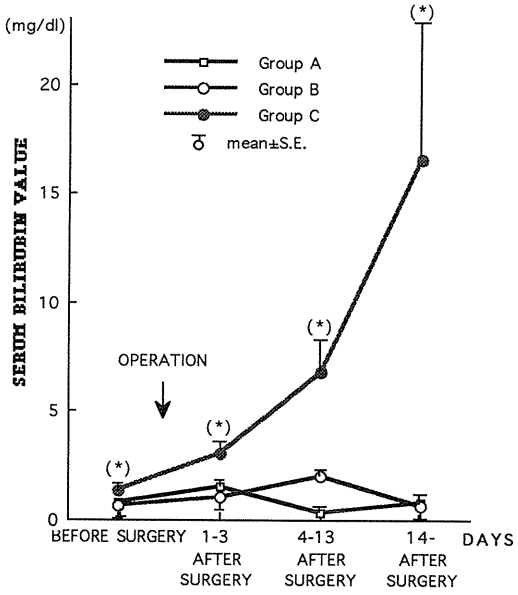

Fig. 1 Perioperative changes in the mean of the maximum bilirubin values. The perioperative mean values of the maximum bilirubin values in Group C were significantly higher than those in Group A and B. (*) indicates $P<0.05$ compared to Group A and B.

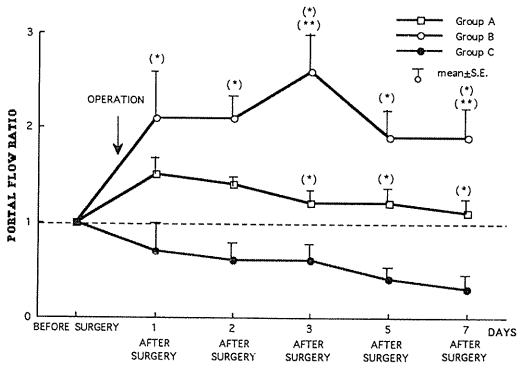

Fig. 2 Perioperative changes in portal flow ratio in the right anterior branch. Portal flow ratio was significantly lower in patients in Group C than those in Group A and B. (*) indicates $P<0.05$ compared to Group C. (**) indicates $P<0.05$ compared to Group A.

gery did show marked decrease, which continued until the last measurement.

Discussion

As a cause of hepatic disorder after major abdominal surgery, decrease in effective hepatic blood flow is often cited (5, 6, 7 ,8), although much remains to be discovered by applying non-invasive, daily observation of portal hemodynamics in liver dysfunction. In this study, *a new approach was used for* the perioperative investigation of portal blood flow and liver function with the pulsed Doppler *ultrasonography. Especially portal blood flow could be accurately calculated from blood flow in the right anterior branch* (5), because the beam-vessel angles detected in the right anterior branch were stable and the distinct ultrasound images were easily obtained.

Daily change of serum bilirubin values after surgery is known to be a reliable parameter of postoperative liver dysfunction. In the present study, the patients undergoing abdominal surgery were divided into three groups according to the time of the postoperative cholestasis, which was compared with the perioperative changes of portal blood flow volume. In patients of Group A and B, portal flow increased during the first few days after surgery and then gradually returned to the preoperative level. In these groups, no serious complications including liver failure occurred. However, in Group C the flow decreased markedly even in the early phase after surgery, and subsequently most of the patients suffered from fatal liver failure. Thus, *the decrease in portal flow, especially during the first several days after surgery was closely reflected to the subsequent occurrence of severe liver damage.*

Ljubicic et al. (9), using pulsed Doppler method, found a relationship between liver function and the magnitude of circulatory alterations in the portal vascular bed in patients with cirrhosis. Pain and Bailly (10) reported that, in non-jaundiced patients undergoing surgery, the mean endotoxin level of the portal blood flow was significantly higher than that of the systemic blood. *Shibayama* (11) reported significant sinusoidal circulatory disturbance by microthrombosis in the pathogenesis of hepatic damage and dysfunction due to endotoxin. Some authors reported

that tumor necrosis *factor* plays a role similar to that of endotoxin (12). In the present study, the mean operation time was 352.6± 30 min. in patients without portal flow disturbance (Group A and B), and that was 520.7± 186.7 min. in those with flow disturbance (Group C). *The intraoperative blood loss 693.2± 106.0ml and 1497.5± 773.4ml, respectively.* In addition, liver cirrhosis was observed in 7 of 37 patients without portal flow disturbance, but in 4 of 6 patients with flow disturbance: the proportion of patients with Child's C in the patients with flow disturbance was significantly higher than that in those without flow disturbance. *The author* speculate that intraoperative risk factors, such as prolonged operation time or a large quantity of blood loss, increased the endotoxin concentration, and that sinusoidal circulatory disturbance reduced the portal blood flow, especially in patients with poor condition of the liver, viz., those with liver cirrhosis. Correlations between portal blood flow and bile flow and between bile flow and hepatocellular ATP have been experimentally demonstrated; viz., when portal flow decreased, hepatic cellular ATP decreased and bile flow subsequently decreased (13,14). Bradford et al. (15) also reported that 75% decrease of flow was followed by hepatocyte damage of the central zone. From this perspective, it is easy to speculate that out-flow disturbance of the hepatic circulation will occur under prolonged portal flow disturbance. In our study, the patients whose flow disturbance was found in the early phase after surgery suffered from subsequent liver failure. It seems reasonable to speculate that these hepatic blood flow disturbance may precipitate liver damage.

The conclusion is as follows; there is a relationship between liver failure after surgery and circulatory impairment in the right anterior branch of the portal vein, *and the measurement of portal blood flow of this branch before and after surgery with pulsed Doppler ultrasonographic flowmeter* is *useful for estimation of liver* damage, *so that marked decrease of blood flow in* the first several days after surgery is prognostic signs of subsequent severe liver failure.

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