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Control of Intraoperative Bleeding During Liver Resection: Analysis of a Questionnaire Sent to 231 Japanese Hospitals

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Abstract To determine the safest and most efficient way of performing hepatectomy, the differences in methods employed by Japanese surgeons were examined. In November 1998, a questionnaire on bleeding control during hepatectomy was sent to 270 hospitals located throughout Japan. The answers from 231 hospitals (85.6%) were analyzed. Surgical apparatus such as an ultrasonic dissector (USD) was used in 203 hospitals. Pringle's maneuver was performed routinely in 25%, for segmentectomy and subsegmentectomy in 25%, for lobectomy in 9%, depending on the situation in 34%, and never in 7%. In 135 hospitals (60%), hemostatic materials such as fibrin glue were always applied to the cut surface after hepatectomy. The USD was chosen and widely accepted by the hospitals studied. As Japanese patients with hepatoma often have liver cirrhosis, intermittent occlusion and the selective clamping of hepatic inflow were considered preferable to persistent inflow occlusion. The gentle exposure of hepatic venous branches, careful hemostasis during hepatectomy, and accurate location of the hepatic vein by intraoperative ultrasonography were all considered to be extremely important.

Key words Hepatectomy · Surgical apparatus · Bleeding control · Questionnaire

Introduction

Advances in surgical techniques and management have enabled liver resection to be safely performed; however, bleeding during liver surgery is sometimes massive and difficult to control. Surgical apparatus such as the ultrasonic dissector (USD), water jet knife (WJK), microwave coagulator (MCT), and harmonic scalpel (HMS) are used to resect the hepatic parenchyma. During parenchymal resection, we do not routinely perform Pringle's maneuver and the instruments used to perform hepatectomy and the methods of controlling intraoperative bleeding differ among hospitals with each surgeon. Despite this fact, to our knowledge there has been no report on those differences in our country. The aim of this study was to examine the differences in opinion of many Japanese surgeons to determine the safest and most reliable method of performing hepatectomy.

Methods

Participating Hospitals

In November 1998, a questionnaire was sent to 270 Japanese hospitals that were considered to have performed ten or more hepatectomies each year for any type of liver diseases. A total of 231 hospitals (85.6%) answered the questionnaire according to the data over the last few years. These hospitals were located throughout Japan, from Hokkaido Prefecture, the northernmost part of the country, to Okinawa Prefecture, the southernmost part.

Questionnaire

The questionnaire comprised nine questions as the following aspects of hepatectomy.

1. The basis of the hospitals
2. The number of hepatectomies performed each year
3. The surgical equipment used for resection of the hepatic parenchyma

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4. Occlusion of the hepatic blood inflow during resection of the hepatic parenchyma
5. and 6. Control of intraoperative bleeding during hepatectomy
7. and 8. The use of hemostatic materials on the resected surface after hepatectomy
9. Comments about operative bleeding control during hepatic resection

All data were analyzed and statistical comparison was carried out by the χ^2, Mann-Whitney, and Wilcoxon tests. A P value of less than 0.05 was considered statistically significant.

Results

Types of Hospitals

Of the 231 hospitals that participated in the survey, 57 were university hospitals; national ($n = 30$), prefectural ($n = 5$), and private ($n = 22$). The remaining 174 were national ($n = 14$), public ($n = 80$), private ($n = 48$), and others such as Red Cross hospitals ($n = 32$).

Number of Hepatectomies Performed Each Year

The hospitals were divided into five groups according to the number of hepatectomies performed each year, namely, less than 10, 40 (17.3%), 10–30, 133 (57.6%), 30–50, 42 (18.2%), 50–100, 13 (5.6%), and more than 100, 3 (1.3%). Of the 40 (95%) hospitals performing less than ten hepatic resections each year, 38 were nonuniversity hospitals. More than 100 hepatectomies each year were performed only in three major university hospitals (Table 1).

Surgical Equipment Used for Resection of the Hepatic Parenchyma

The USD was ranked the first choice of surgical apparatus used for hepatic parenchymal resection by 161 hospitals (71.5%). The MCT, HMS, and WJK were ranked as first choice by 27 (11.9%), 11 (4.8%), and 4 hospitals (1.7%), respectively. No specialized equipment was used by 20 hospitals (8.8%) (Table 1).

The surgical apparatus ranked second or used in combination with USD was MCT, HMS, and WJK in 70, 18, and 1 hospitals, respectively. Of the 27 hospitals that ranked MCT as first choice, USD, HMS, and WJK were ranked second or used in combination with MCT in 8, 6, and 3 hospitals, respectively (Table 2).

Occlusion of Hepatic Blood Inflow During Resection of the Hepatic Parenchyma

During resection of the hepatic parenchyma, total hepatic inflow occlusion at the porta hepatis (Pringle's maneuver) was always carried out in 58 hospitals (25.1%). In 21 hospitals (9.1%), it was only carried out when lobectomy or hepatectomy larger than lobectomy was performed; in 37 (16.0%), when segmentectomy or larger was performed, and in 21 (9.1%) when subsegmentectomy or partial resection was performed. In 15 hospitals (6.5%), Pringle's maneuver was never carried out, and in 79 hospitals (34.2%), it was carried out according to the situation, for example, if massive bleeding occurred.

Of the 203 hospitals using surgical apparatus for resection of the hepatic parechyma, Pringle's maneuver was always performed in 44 (21.8%) and never performed in 15 (7.4%) (Table 3). All of the 20 hospitals using no surgical apparatus performed Pringle's maneuver at the same time, and the rate of routinely carrying

Table 1. Number of hepatectomies performed each year and surgical apparatus used as the first choice for resection of hepatic parenchyma

	Number of hepatectomies performed each year					
Surgical apparatus	<10 (40)	10–30 (133)	30–50 (42)	50–100 (13)	>100 (3)	Total (%) (231)
USD	26	99	28	6	2	161 (71.2)
MCT	8	12	6	1	0	27 (12.0)
HMS	1	6	3	1	0	11 (1.7)
WJK	2	2	0	0	0	4 (4.9)
None	3	8	5	4	0	20 (8.9)
Others	0	2	0	0	1	3 (1.3)
Total	40	129	42	12	3	226 (100)

USD, ultrasonic dissector; MCT, microwave coagulator; HMS, harmonic scalpel; WJK, water jet knife

Table 2. Surgical apparatus ranked second or used together with the first-choice apparatus documented in Table 1

Apparatus ranked first choice	Apparatus ranked second or used together with those ranked first					
	USD	MCT	HMS	WJN	None	Total
USD (161)	—	70	18	1	1	90
MCT (27)	8	—	6	3	1	18
HMS (11)	3	2	—	0	0	5
WJK (4)	0	2	2	—	0	4
None (20)	3	2	0	0	—	5

USD, ultrasonic dissector; MCT, microwave coagulator; HMS, harmonic scalpel; WJK, water jet knife

Table 3. Use of surgical apparatus and occlusion of hepatic blood inflow during resection of hepatic parenchyma

Use of surgical apparatus	Hepatic blood inflow occlusion (Pringle's maneuver)			
	Always	According to indication	Never	Total
Yes	44 (21.8)	143 (70.8)	15 (7.4)	202
No	12 (60.0)	8 (40.0)	0	20

Table 4. Number of hepatectomies performed each year and the location where blood control proved most difficult in liver resection

Location where blood control was difficult	Hepatic resections performed each year (%)				
	<10	10–30	30–50	≥50	Total
Hepatic hilum	0	5 (4.0)	0	0	5 (2.3)
Cut surface	12 (32.4)	24 (19.2)	5 (13.5)	1 (6.3)	42 (19.5)
Hepatic vein	24 (64.9)	94 (75.2)	32 (86.5)	14 (87.4)	164 (76.3)
Others	1 (2.7)	2 (1.6)	0	1 (6.3)	4 (1.9)
Total	37 (100)	125 (100)	37 (100)	16 (100)	215 (100)

out that maneuver was 60%, which was significantly higher than that in the former group of hospitals ($P = 0.00206$).

Control of Intraoperative Bleeding During Liver Resection

According to the questionnaire, the frequency could be expressed as "often," "sometimes," "unusually," or "rarely." The percentages of the four classifications were 2.2%, 37.0%, 45.1%, and 15.7%, respectively, and there was no correlation with the number of hepatectomies, the use of equipment, or the execution of Pringle's maneuver.

The locations where the hemostasis proved difficult were: "the hepatic hilum," "the cut surface of the liver," "the hepatic vein," and "others." "The hepatic vein" was where bleeding control proved most difficult (76.3%) and the incidence of bleeding problems in this location increased according to the number of hepatectomies performed ($P = 0.00287$) (Table 4).

The frequency and location of "difficult bleeding control" were not related to whether Pringle's maneuver was performed, or if surgical apparatus was used.

The Use of Hemostatic Materials on the Cut Surface After Hepatectomy

In 135 hospitals (59.2%), hemostatic materials were always applied to the cut surface after liver resection. In 47 hospitals (20.6%), they were applied to the resected surface under conditions such as oozing from the hepatic parenchyma, in 42 (18.4%) under conditions such as lobectomy or hepatectomy larger than lobectomy, and in 2 (0.9%) with bile leakage. They were not used at all in two hospitals (0.9%). The use of hemostatic

Table 5. Use of surgical apparatus and hemostatic materials on the cut surface after hepatectomy

Use of surgical apparatus	Always	If oozing	Lobectomy	Bile leak	No use	Total
Yes	114	41	41	1	2	199
No	14	5	1	0	0	20
Total (%)	128 (58.4)	46 (21.0)	42 (19.2)	1 (0.5)	2 (0.9)	219 (100)

materials on the cut surface after hepatectomy was not related to the number of hepatectomies, whether or not Pringle's maneuver was performed, or what surgical apparatus was used for resection (Table 5).

The most frequently used hemostatic materials were fibrin glue (155), oxygenated cellulose (35), and collagen sheet (28).

Comments About Intraoperative Bleeding Control During Hepatic Resection

The various comments on bleeding control were summarized as follows.

1. Gentle handling of the hepatic vein and its branches is of great importance (31)
2. Careful hemostasis during hepatic parenchymal resection must be ensured (24)
3. The preferred methods of hemostasis stipulated by 14 hospitals were: (a) compression (4), (b) ligature (4), (c) suture (3), (d) others (3)
4. Identification of the intrahepatic vessels using intraoperative ultrasonography is important (11)
5. Especially careful surgery is required for the cirrhotic liver (8)
6. Maintaining a clear and wide operative field is important (8)
7. The prevention of intraoperative high venous pressure must be ensured (7)
8. Preparation for hepatic vein clamping or total vascular clamp is necessary before hepatic resection (6)
9. Other comments (4)

Discussion

Almost 90% of the 231 hospitals surveyed used some type of apparatus to control bleeding during hepatic resection, the USD being the most widely accepted, ranked first in more than 70% of institutions. In the other 20 hospitals, no particular surgical apparatus was utilized for hepatectomy, and hepatic inflow occlusion was frequently performed in this group.

With regard to bleeding control during hepatic parenchymal resection, there were many opinions on Pringle's maneuver. In fact, 15 hospitals (6.5%) never performed Pringle's maneuver, the reason for which was not questioned, although we considered that they feared postoperative hepatic functional disorder might result if this method was used, as most hepatoma patients in Japan have chronic hepatitis or cirrhosis.[1]

On the other hand, 25% of the hospitals routinely used Pringle's maneuver and were fully convinced of its safety. It was reported that if Pringle's maneuver was completed within an hour, it was safe for hepatic resections without liver cirrhosis[2] and that if it was completed within 30 min, it was safe even for patients with liver cirrhosis.[3] However, the safe time limit for performing Pringle's maneuver in patients with a cirrhotic liver has not been clearly established, and therefore this method should be avoided in patients with severe hepatic dysfunction. In our department, we usually perform this maneuver when a hepatoma is located on the Cantlie line and its blood supply comes from both the right and left hepatic arteries, or when unpredictable bleeding from the hepatic artery or portal vein occurs during hepatectomy. In patients with cirrhosis, intermittent occlusion is advisable because it has been reported to reduce hepatic parenchymal damage.[4,5] When anterior, posterior, or lateral segmentectomy needs to be performed in a patient with liver cirrhosis, selective clamping is considered to be more favorable and safer than total inflow occlusion.[6]

The point where bleeding proved most difficult to control was frequently reported as the hepatic vein. In this questionnaire, the incidence of this location increased in accordance with the number of hepatectomies performed in each institution. In other words, blood control from the hepatic hilum or cut surface can be fully achieved by accumulated "experiences," but this is not necessarily true for bleeding from the hepatic vein or its branches.

There were numerous comments and opinions on bleeding control during hepatectomy. Many Japanese surgeons pointed out that gentle exposure of hepatic venous branches, careful hemostasis during hepatic parenchymal resection, and confirming the location of the hepatic vessels by intraoperative ultrasonography were extremely important.

In this questionnaire, no question regarding hepatic vein clamping or total hepatic vascular occlusion was asked. While we do not routinely clamp the hepatic vein, if the hepatic vein is involved in the area to be resected, exposure of the hepatic vein or suprahepatic vena cava should be prepared before liver resection. The safety limit of hepatic vascular occlusion varies from 60 to 90 min.[7–9] In combination with veno-venous bypass, patients with cirrhosis were able to tolerate up to 60 min of total vascular occlusion.[10] When total vascular clamping is necessary, pre- and intraoperative intensive preparation is essential.

In this survey, hemostatic materials were often used on the cut surface after liver resection to prevent postoperative bleeding. This is of course strongly related to the fact that Japanese patients with hepatoma frequently have chronic hepatic dysfunction caused by hepatitis B virus (HBV) or/and hepatitis C virus (HCV) infection. It has been reported that careful surgical hemostatic measures using ligatures and sutures are necessary prior to the application of these materials.[11,12] However, no clear indication for the use of topical hemostatic agents has been standardized. As hemostatic materials are totally or partially left as a foreign body in the patient's abdominal cavity, and from an economic viewpoint, appropriate case selection is considered to be essential.

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