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Prospective Evaluation of Pringle Maneuver in Hepatectomy for Liver Tumors by a Randomized Study

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Objective
To evaluate whether vascular inflow occlusion by the Pringle maneuver during hepatectomy can be safe and effective in reducing blood loss.

Summary Background Data
Hepatectomy can be performed with a low mortality rate, but massive hemorrhage during surgery remains a potentially lethal problem. The Pringle maneuver is traditionally used during hepatectomy to reduce blood loss, but there is a potential harmful effect on the metabolic function of hepatocytes. There has been no prospective randomized study to determine whether the Pringle maneuver can decrease blood loss during hepatectomy, improve outcome, or affect the metabolism of hepatocytes.

Methods
From July 1995 to February 1997, we studied 100 consecutive patients who underwent hepatectomy for liver tumors. The patients were randomly assigned to liver transection under intermittent Pringle maneuver of 20 minutes and a 5-minute clamp-free interval (n = 50), or liver transection without the Pringle maneuver (n = 50). The surface area of liver transection was measured and blood loss during transection per square centimeter of transection area was calculated. Routine liver biochemistry, arterial ketone body ratio (AKBR), and the indocyanine green (ICG) clearance test were done.

Results
The two groups were comparable in terms of preoperative liver function and in the proportion of patients having major hepatectomy. The Pringle maneuver resulted in less blood loss per square centimeter of transection area (12 mL/cm^2 *vs.* 22 mL/cm^2, $p = 0.0001$), a shorter transection time per square centimeter of transection area (2 min/cm^2 *vs.* 2.8 min/cm^2, $p = 0.016$), a significantly higher AKBR in the first 2 hours after hepatectomy, lower serum bilirubin levels in the early postoperative period, and, in cirrhotic patients, higher serum transferrin levels on postoperative days 1 and 8. The complication rate, the hospital mortality rate, and the ICG retention at 15 minutes on postoperative day 8 were equal for the two groups.

Conclusion

Performing the Pringle maneuver during liver transection resulted in less blood loss and better preservation of liver function in the early postoperative period. This is probably because there was less hemodynamic disturbance induced by the bleeding.

Hepatectomy can be associated with torrential bleeding, especially when the liver is affected by chronic hepatitis or cirrhosis. Although hemostasis can be achieved, the postoperative morbidity and mortality rate may increase,[1] the chance of transmission of infectious disease by blood transfusion is higher, and the duration of cancer-free survival is shorter than in patients who do not require blood transfusion.[2] To decrease bleeding during hepatectomy, the Pringle maneuver is the most commonly used procedure. However, the Pringle maneuver may induce ischemic injury to the liver, the degree of which may be accentuated in the presence of cirrhosis.[3] However, some surgeons perform hepatectomy without any kind of vascular control, with results claimed to be equally favorable.[4–7]

The role of the Pringle maneuver is therefore controversial. To the present, there has been no prospective randomized study to document its safety and efficacy. Therefore, we carried out a prospective randomized trial to determine whether the Pringle maneuver is safe and effective in reducing blood loss during hepatectomy.

METHODS

Randomization

From July 1995 through February 1997, 100 consecutive patients (age >18 years) whose tumors were considered to be resectable on the basis of intraoperative ultrasonography were randomly assigned to undergo hepatectomy with intermittent Pringle maneuver (Pringle group = 50 patients) or no Pringle maneuver (control group = 50 patients). Patients who required concomitant bowel resection were not included. The intermittent Pringle maneuver was applied at the time of liver transection and consisted of cross-clamping the hepatoduodenal ligament (and the aberrant left hepatic artery if present) for 20 minutes and releasing the clamp for 5 minutes until the liver transection was completed. In the case of segmentectomy for a small tumor (n = 7), only the ipsilateral portal pedicle was clamped. No drugs for protecting the liver from ischemic injury (*e.g.*, steroids) were used during the Pringle maneuver. In all cases, liver transection was performed by an ultrasonic dissector.

Major hepatectomy was defined as the resection of two or more liver segments according to Goldsmith and Woodburne.[8] For all the cases of major hepatectomy, hilar dissection was used to ligate and divide the ipsilateral hepatic artery and portal vein. Minor hepatectomy was defined as the resection of only one segment.

The study protocol was approved by the ethics committee of The University of Hong Kong. Informed consent was obtained from every patient before the operation.

Preoperative Assessment

All patients had the indocyanine green (ICG) clearance test[9] and measurement of arterial ketone body ratio (acetoacetate/β-hydroxybutyrate, AKBR) and serum transferrin, in addition to the routine liver and renal biochemistry. AKBR was performed by the method described by Ozawa,[10] using Ketorex kits (Sanwa, Nagoya, Japan) and a spectrophotometer (KETO-340 II; Sanwa Kagaku Kenkyusho, Japan). Transferrin was measured by rate nephelometry using a Beckman Array Analyzer (Fullerton, CA).

Intraoperative Assessment

A liver biopsy was obtained, before hilar dissection, by the freeze-clamp method for the measurement of liver tissue adenosine triphosphate (ATP) content. After liver transection, another specimen was obtained for comparison. The liver tissues were stored at −70 C for measurement of ATP content using the ATP Bioluminescence Assay kit HS II[11] (Boehringer Mannheim, Germany) and a luminometer (Model 2020; Turner Designs, Sunny Vale, CA). A 3-mm cube of liver tissue was also obtained before and after liver transection for histologic evidence of ischemic injury.

AKBR was measured before, during, and after liver transection and then hourly for 4 hours. Accurate measurements of blood loss were made before, during, and after liver transection. The volume of blood loss was measured from the weight of the soaked gauze and blood collected from the containers of the suction apparatus and ultrasonic dissector. The volume of irrigation fluid was deducted accordingly. The blood loss was assessed in three phases of hepatectomy because the efficacy of the

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Pringle maneuver was measured mainly by the amount of blood loss during the transection phase.

After completion of the liver transection, the transection surface was placed on a transparent plastic sheet. It was immediately transcribed onto a piece of graph paper to measure the area of liver transection surface. The blood loss during liver transection was expressed as mL/cm^2 of liver transection surface. Similarly, the liver transection time was expressed as min/cm^2 of liver transection surface. The liver transection time was measured from the beginning to the end of liver transection. Ischemic time was the total duration of application of the Pringle maneuver. The clamp-free period exceeded 5 minutes in some patients because the bleeding vessels on the transection surface were sutured during that period.

Postoperative Assessment

AKBR was measured after the operation daily for the first 2 days. Serum transferrin was measured on postoperative days 1, 4, and 8. Routine hematologic tests and liver and renal biochemistry were performed daily for 7 days. The ICG clearance test was repeated on postoperative day 8. The duration of hospital stay and the incidence of morbidity and hospital mortality were compared between the two groups.

Statistical Analysis

The results are expressed as medians and ranges. The Mann-Whitney U test was used to compare continuous variables. The chi square test was used to compare discrete variables. Significance was defined as a p value <0.05. Calculations were made with the help of SPSS computer software (Chicago, IL).

RESULTS

The two groups of patients were similar in terms of age, sex, results of preoperative assessment (Table 1), proportion undergoing major or minor hepatectomy (Table 2), incidence of underlying cirrhosis, tumor size, and nature of the liver tumor (Table 3). The operations were performed by five different surgeons: 2 of them had experience in >200 hepatectomies and were familiar with liver transection without the Pringle maneuver, and the other 3 had experience in <50 hepatectomies.

The Pringle maneuver was employed intermittently for ≤201 minutes (see Table 2). In one patient in the Pringle group, conversion to total vascular occlusion was necessary to control torrential bleeding from the hepatic vein near the inferior vena cava by clamping the suprahepatic and infrahepatic inferior vena cava. None of the patients in the control group needed conversion to the Pringle maneuver.

Table 1. PREOPERATIVE DATA OF PATIENTS WITH HEPATECTOMY USING PRINGLE MANEUVER AND CONTROL PATIENTS

	Pringle Group (n = 50)	Control Group (n = 50)
Age (yr)	59 (19–79)	52.5 (25–80)
Sex (M/F)	40:10	41:9
Hemoglobin (g/L)	14.1 (8.7–17.0)	13.75 (8.6–16.5)
Platelet count ($\times 10^9$/L)	191 (52–479)	198.5 (65–421)
Prothrombin time (sec)	11.1 (9.5–15.3)	10.9 (9.4–13.9)
Serum bilirubin (μmol/L)	11.0 (3.0–34.0)	11.0 (5.0–27.0)
Serum aspartate aminotransferase (U/L)	39 (10–283)	36 (16–227)
Serum alanine aminotransferase (U/L)	38 (8–174)	34 (8–344)
Serum albumin (g/L)	41 (30–50)	41 (23–50)
Serum transferrin (g/L)	1.8 (0.7–2.9)	1.7 (0.9–2.6)
Arterial ketone body ratio	0.88 (0.18–3.1)	0.86 (0.15–3.2)
Indocyanine green retention % at 15 min	8.7 (1.4–52.7)	8.4 (1.6–26.5)
Adenosine triphosphate ($\times 10^{-8}$ g/g liver)	68 (1–1424)	41.4 (1–194)

Values are median (range).

Blood loss during liver transection was significantly lower in the Pringle group than in the control group (see Table 2). The blood loss per square centimeter of transection area was also significantly less. The Pringle group had a significantly lower transfusion requirement, and there were more patients who did not require blood transfusion. The time required for liver transection (per square centimeter of transection area) was also less in the Pringle group than in the control group (see Table 2).

In the first 2 hours after liver transection, the AKBR was significantly better in the Pringle group than in the control group (Fig. 1A). The serum total bilirubin level on the day of surgery and postoperative day 1 was also lower in the Pringle group than in the control group (Fig. 2A). There was no significant difference between the two groups in prothrombin time, liver enzyme levels, serum transferrin, ICG retention rate at 15 minutes measured on postoperative day 8 (median 11.7% in the Pringle group *vs.* 14.9% in the control group), and the change (preoperative value minus postoperative value) in ICG retention rate at 15 minutes (median −3.2% in the Pringle group *vs.* median −7.05% in the control group). There was no histologic evidence of necrosis of hepatocytes in either group. The ATP content of liver biopsy was about the same in both groups of patients after liver transection (median 52×10^{-8} g/g liver in the Pringle group *vs.* 40×10^{-8} g/g liver in the control group).

Postoperative complications occurred in 13 patients in the Pringle group (26%) and in 15 patients in the control group (30%) (Table 4). One patient in the Pringle group developed subphrenic abscess and died of septicemia. Her

Table 2. INTRAOPERATIVE DATA OF PATIENTS WITH HEPATECTOMY USING PRINGLE MANEUVER AND CONTROL PATIENTS

	Pringle Group (n = 50)	Control Group (n = 50)	p
Major hepatectomy	34	35	
Right hepatic lobectomy	24	21	
Right extended lobectomy	5	9	
Left hepatic lobectomy	4	4	
Left extended lobectomy	1	1	
Minor hepatectomy	16	15	
Left lateral segmentectomy	7	6	
Subsegmentectomy	9	9	
Ischemic time (min)	88 (24–101)	0	
Total blood loss (L)	1.28 (0.33–9.42)	1.99 (0.26–13.9)	0.006*
Blood loss during liver transection (L)	0.61 (0.09–8.5)	1.41 (0.17–11.4)	0.0002*
Transection surface area (cm^2)	68 (22–130)	60.5 (16–155)	0.064
Blood loss per transection area (mL/cm^2)	12 (3–74)	22 (5–150)	0.0001*
Blood transfusion (L)	0 (0–8.6)	0.6 (0–12.9)	0.02*
Patients without blood transfusion	32	21	0.028*
Liver transection time (min)	138 (33–300)	169 (40–463)	0.162
Liver transection time (min/cm^2)	2 (1–3.6)	2.8 (0.2–6)	0.016*

Values are median (range).
* Significant value.

blood loss during liver transection was 300 mL only, and the ischemic time was 85 minutes. In the control group, 1 patient had sudden deterioration of liver function on postoperative day 7. On computed tomography, she was found to have superior mesenteric vein thrombosis and infarction of the liver remnant. She died of liver failure.

Table 3. PATHOLOGIC DATA OF PATIENTS WITH HEPATECTOMY USING PRINGLE MANEUVER AND CONTROL PATIENTS

	Pringle Group (n = 50)	Control Group (n = 50)
Tumor size (cm) [median (range)]	6.8 (2–23)	6.5 (0.3–15)
Nontumorous liver		
Cirrhosis	13	16
Chronic hepatitis	18	12
Normal	19	22
Pathologic diagnosis		
Hepatocellular carcinoma	37	36
Cholangiocarcinoma	1	0
Mixed hepatocholangiocarcinoma	2	3
Colorectal liver secondary	5	8
Focal nodular hyperplasia	1	2
Lymphoma	0	1
Inflammatory pseudotumor	2	0
Angiomyolipoma	1	0
Cavernous hemangioma	1	0

Her blood loss during liver transection was 750 mL only. Another patient in the control group suffered preoperatively from chronic renal failure. His renal function deteriorated and he died on postoperative day 87. He lost 1.5 L of blood during liver transection and received 0.6 L of blood transfusion.

The data were further analyzed to determine whether patients with underlying chronic liver diseases responded to the Pringle maneuver differently. Patients with cirrhosis subjected to the Pringle maneuver had better outcomes than patients in the control group: the transection time per square centimeter of transection area, the volume of blood loss during transection, the volume of blood loss per square centimeter of transection area, the volume of blood transfusion, and the number of patients requiring blood transfusion were significantly less than those of the control group (Table 5). The serum transferrin level of cirrhotic patients was higher in the Pringle group on postoperative days 1 and 8 than in the control group (Fig. 3). In patients with chronic hepatitis, a significant difference between the two groups was seen only in the measurement of AKBR immediately after transection (Fig. 1B). In patients with normal liver, the benefits in terms of transection time and blood loss were again observed (see Table 5), and the AKBR measured in the first 3 hours after liver transection was significantly higher in the Pringle group than in the control group (Fig. 1C). The serum total bilirubin level was also significantly lower on postoperative days 1 to 6 (Fig. 2B). However, serum alanine amino-

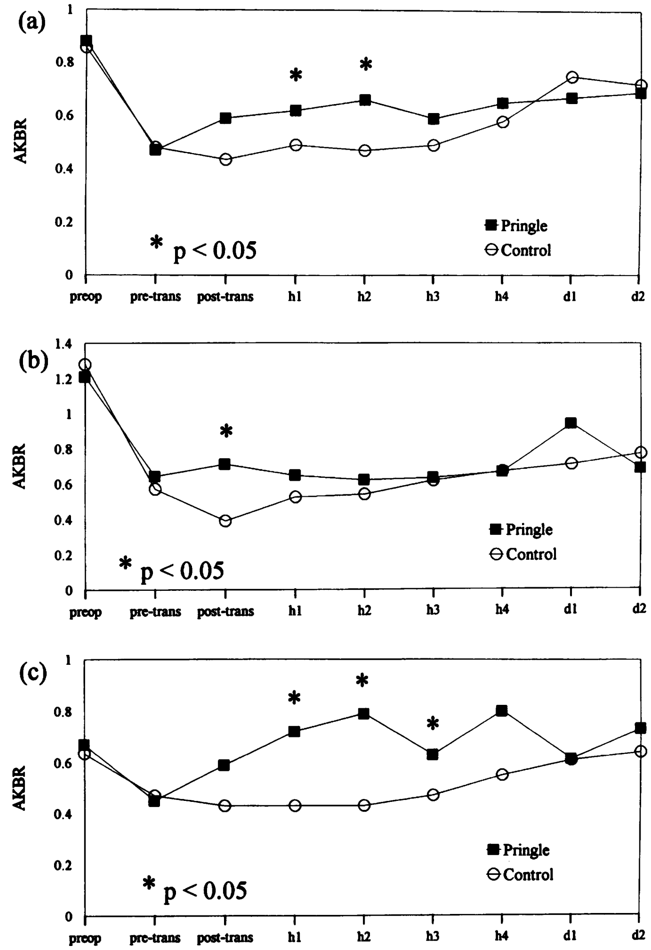

Figure 1. Time course of arterial ketone body ratio (AKBR) of (A) all patients, (B) patients with chronic hepatitis, and (C) patients with normal liver. Preop, before operation; pre-trans, immediately before liver transection; post-trans, immediately after liver transection; h, hour; d, day.

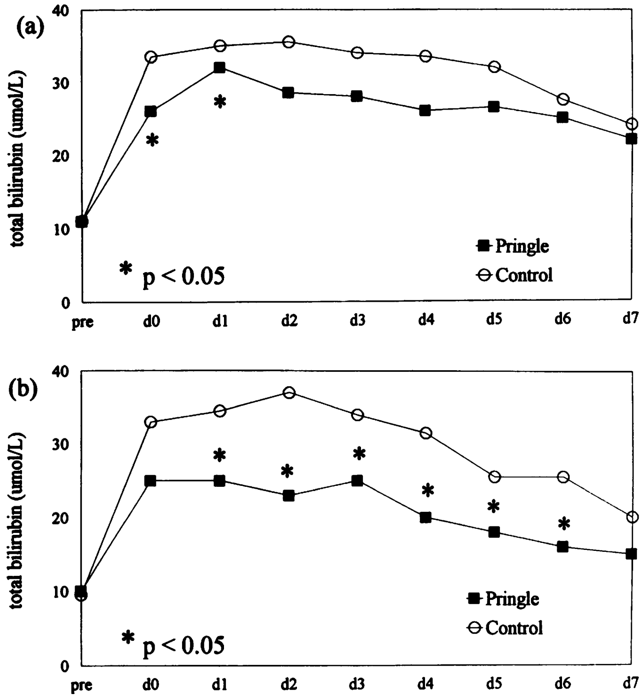

Figure 2. Time course of serum total bilirubin of (A) all patients and (B) patients with normal liver. Pre, before operation; d, day.

transferase levels were higher than those of the control group throughout the first week after surgery (Fig. 4).

The results were further analyzed according to the level of experience of the surgeons (Table 6). The benefit of the Pringle maneuver in terms of reduction of blood loss was the same irrespective of the level of experience, although a wider range of blood loss between the Pringle group and the control group was observed in patients operated on by less experienced surgeons. The transection time per square centimeter of transection area was significantly reduced in patients operated on by experienced surgeons using the Pringle maneuver, but not in those operated on by less experienced surgeons (see Table 6).

DISCUSSION

With refinements in surgical technique, improvements in perioperative care, and better criteria for patient selection, hepatectomy can today be performed with a mortality rate <5%. Avoidance of excessive bleeding and blood transfusion is now the target of most liver surgeons. Thus,

Table 4. OVERALL POSTOPERATIVE MORBIDITY AND HOSPITAL MORTALITY

	Pringle Group (n = 50)	Control Group (n = 50)
Complication*		
Pulmonary sepsis	4	8
Wound infection	3	4
Subphrenic abscess	1 (1)	0
Biliary fistula	1	1
Pseudomembranous colitis	1	0
Limb cellulitis	1	0
Pleural effusion	3	6
Wound dehiscence	0	1
Intra-abdominal bleeding	1	1
Bleeding peptic ulcer	2	1
Superior mesenteric vein thrombosis	0	1 (1)
Uremia	0	1 (1)
Pulmonary edema	2	1
Length of hospital stay (days) [median (range)]	11 (6–27)	10 (7–87)
Hospital mortality	1	2

* Values in parentheses are the number of patients dying from the complication.

Table 5. INTRAOPERATIVE DATA OF PATIENTS WITH DIFFERENT LIVER STATUS

	Cirrhosis		Chronic Hepatitis		Normal Liver	
	Pringle Group (n = 13)	Control Group (n = 16)	Pringle Group (n = 18)	Control Group (n = 12)	Pringle Group (n = 19)	Control Group (n = 22)
Major hepatectomy	7	9	14	10	13	16
Ischemic duration (min)	80 (24–130)	0	100 (31–175)	0	88 (40–201)	0
Transection time (min)	113 (33–212)*	163 (89–260)	177 (55–264)	135.5 (89–243)	141 (67–300)	180 (40–463)
Transection time (min/cm²)	2.1 (0.9–2.8)*	3.0 (1.6–5.3)	2.3 (1.5–3.5)	2.1 (1.1–4.2)	1.9 (1.2–3.6)*	2.5 (1.2–6.1)
Blood loss during transection (L)	0.5 (0.28–2.6)*	1.3 (0.44–5.35)	0.66 (0.09–8.5)	1.24 (0.31–6.0)	0.76 (0.30–5.93)*	1.46 (0.17–11.4)
Blood loss per transection area (mL/cm²)	11 (5–29)*	27 (9–98)	10 (4–74)	21 (5–83)	12 (3–46)*	22 (1–150)
Blood transfusion (L)	0 (0–1.6)*	0.7 (0–9.0)	0 (0–3.6)	0 (0–12.9)	0.15 (0–86)	0.6 (0–9.9)
Patient without blood transfusion	11*	7	12	7	9	7

* $p < 0.05$ *vs.* control group.

many surgical techniques for vascular control during hepatectomy have been advocated, including total vascular exclusion,[12] continuous Pringle maneuver or hepatic vascular exclusion,[13] intermittent Pringle maneuver,[14,15] balloon occlusion of the inflow[16] or outflow blood vessels,[17] selective inflow clamping,[18] and supraceliac aortic clamping.[19] Of these procedures, the Pringle maneuver is the simplest to apply.

The Pringle maneuver was claimed to be effective in reducing blood loss, but it was evaluated in only two retrospective studies. Nagasue et al.[4] compared the outcome of 20 patients without the Pringle maneuver with that of 73 patients with the Pringle maneuver. They reported that the use of the Pringle maneuver was associated with less blood loss but a higher complication rate. Taniguchi et al.[5] demonstrated that blood loss and operative time were similar whether the Pringle maneuver was used or not, but the postoperative serum bilirubin and liver enzymes were elevated in the group with the Pringle maneuver. They concluded that the Pringle maneuver might not be necessary for a successful hepatectomy.

We found the Pringle maneuver to be beneficial in reducing blood loss and in shortening the time to complete the liver transection. It resulted in a reduction in the volume of blood transfusion, and only one third of the patients needed blood transfusion (see Table 2). It was also shown to be a useful procedure irrespective of the level of experience of the surgeon.

Liver transection is today performed mostly by an ultrasonic dissector, but this is slow. We therefore decided to use an intermittent rather than a continuous[13] Pringle maneuver to avoid prolonged ischemic injury to the liver. The procedure, moreover, is not entirely bloodless, because the ultrasonic dissector may damage the hepatic vein.[6] In fact, after ipsilateral inflow vascular control or the Pringle maneuver, the major source of bleeding is from the branches of the hepatic vein. Application of the Pringle maneuver can render the surgical field relatively bloodless; as a result, the branches of the hepatic veins can be visualized clearly before they are damaged. We also observed that the hepatic veins were less engorged after application of the Pringle maneuver. Therefore, even

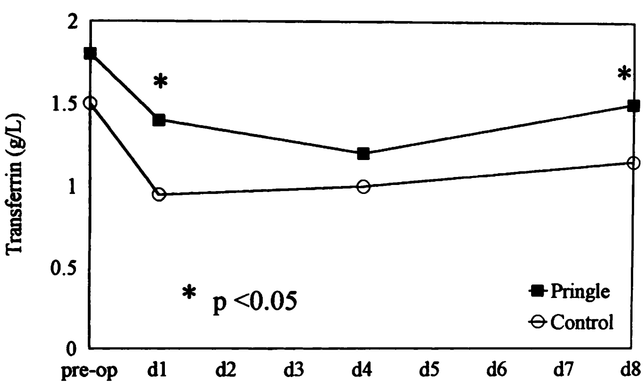

Figure 3. Time course of serum transferrin levels of cirrhotic patients. Pre-op, before operation; d, day.

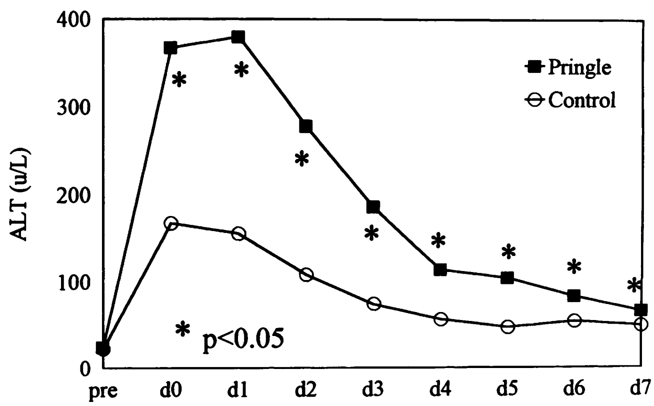

Figure 4. Time course of serum alanine aminotransferase (ALT) levels of patients with normal liver. Pre, before operation; d, day.

Table 6. COMPARISON OF OUTCOME BETWEEN PATIENTS OPERATED BY SURGEONS OF DIFFERENT LEVELS OF EXPERIENCE

	Pringle Group	Control Group	p
Experienced surgeon	(n = 30)	(n = 28)	
Blood loss during transection (L)	0.69 (0.25–5.93)	1.06 (0.17–11.4)	0.044*
Blood loss per transection area (mL/cm²)	12 (3–46)	19 (5–150)	0.008*
Transection time (min/cm²)	2.1 (0.9–3.6)	2.9 (1.1–6.1)	0.002*
Blood transfusion (K)	0 (0–8.6)	0.15 (0–9.9)	0.192
Less experienced surgeon	(n = 20)	(n = 22)	
Blood loss during transection (L)	0.59 (0.09–8.5)	1.74 (0.4–7.08)	0.002*
Blood loss per transection area (mL/cm²)	10 (4–74)	28 (13–90)	0.0002*
Transection time (min/cm²)	2.1 (1.1–3.4)	2.4 (1.4–4.2)	0.099
Blood transfusion (L)	0 (0–3.6)	0.6 (0–12.9)	0.036*

* Significant value.

if they were damaged by the ultrasonic dissector, bleeding could be more easily controlled. The only disadvantage is that bleeding from the transection surface may occur in the clamp-free period and suturing of the bleeding point is required. Nevertheless, intermittent release of the portal clamp allows hemostasis of a small transection area rather than a large area at the end of transection, when hemostasis could be more difficult. As a result of meticulous hemostasis and careful application of the ultrasonic dissector, the liver transection time is long.

Deterioration of liver function is expected after hepatectomy because of the reduction in liver mass, operative trauma, and hypoperfusion of the liver during the bleeding episodes. If vascular inflow occlusion is used, warm ischemic injury[20] and reperfusion injury[21] are possible additional factors. However, our study demonstrated that in the Pringle group, immediate postoperative liver function was better preserved than in patients who were operated on without using the Pringle maneuver. This may be due to less hemodynamic disturbance induced by the bleeding and the fact that even with vascular inflow occlusion, the liver was perfused by retrograde flow from the hepatic vein.[22] Thus, the liver was protected and cell necrosis did not occur. Later in the postoperative week, the liver function of two groups tended to be equal. This may be explained by the rapid regeneration of the liver remnant, particularly in patients with normal livers. The higher serum bilirubin level in patients with normal livers in the control group is probably a result of blood transfusion.

Contrary to our belief,[23] the procedure is equally applicable to patients with cirrhosis. It appeared that patients with cirrhosis benefited more from the maneuver than the other patients in this study. However, the cirrhotic patients chosen for hepatectomy in this study were those with well-compensated liver function. The recommendation may not be appropriate for cirrhotic patients with less compensated liver function. To avoid irreversible injury to the liver, the Pringle maneuver should be applied in an intermittent manner, and the duration should not exceed a total of 120 minutes.

In conclusion, the Pringle maneuver during liver transection is safe and effective and can be employed, in an intermittent manner, during hepatectomy of whatever histology of nontumorous liver.

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Discussion

PROF. C. HUGUET (Monaco): It is a pity that Hogarth Pringle could not be here today. He would have been most happy to hear that what he described in 1908 in Glasgow had just been scientifically confirmed by a prospective randomized study coming from a British colony located in the Far East. I want to congratulate Professor Fan on his presentation and appreciate the opportunity to review the manuscript. I have five comments.

First, the excellent results reported here, either with clamping or not, reflect the expertise of this highly trained team, including 2 senior surgeons with experience of >200 liver resections, and 3 young fellows considered less experienced—but, however, with 50 hepatectomies each. I do not know if any other department in the world has the luck to gather so many experts achieving 100 consecutive liver resections in 18 months.

My second comment addresses methodology. In the case of minor hepatectomy, only the ipsilateral portal pedicle was clamped. The Pringle maneuver was thus avoided in 16 patients out of 50, resulting in no ischemia for the remnant liver. It might have been better to exclude this subgroup of small lesions to avoid this bias.

The third point I would like to bring up is about blood loss. The benefits of clamping are obvious mainly for young surgeons. Absence of clamping resulted in significant differences in blood loss (1.74 L *vs.* 1.06 L). Those with limited experience will benefit more than others from the technical ease brought about by portal pedicle clamping.

The fourth point relates to cirrhotic livers, which are traditionally highly sensitive to ischemia. This work demonstrates that cirrhotic patients with good liver function tolerate normothermic ischemia just as well as other patients, and that a better outcome may be expected when the Pringle maneuver is done. All the biochemical parameters favor clamping, even in the case of a pathologic liver. However, the operative risk is much higher in cirrhotics, and the selection of patients should be very careful.

The last comment concerns intermittent clamping. The authors have demonstrated that the Pringle maneuver is safe and leads to reduced blood loss, but they did not study the effects of continuous clamping, which has the advantage of being technically easier and avoids the ischemia-reperfusion injury sequences resulting from iterative clamping. The biochemical consequences of uninterrupted Pringle maneuver are very mild in our experience. One regrets that this third group was not included in the study.

Again, I would like to emphasize the importance of the message of Professors Wong and Fan. Acceptance of the Pringle maneuver is still limited by concerns regarding induced hepatic ischemia. Deliberate use of vascular clamping, either the Pringle maneuver or hepatic vascular exclusion in the most difficult cases, should be recommended to achieve bloodless liver surgery.

DR. X. ROGIERS (Hamburg, Germany): Thank you very much, Dr. Fan, for giving me the opportunity to read your paper, which I enjoyed very much. You present very strong arguments indeed in favor of the use of the Pringle maneuver. When I look at the results, I remarked also that the transection time per square centimeter of surface area was significantly lower in the Pringle group than in the control group, and since this influences the total blood loss, that leaves me with two questions. Was the transection technique different in the two groups, or is there another factor explaining the slower transection in the control patients? Second, if you calculate the blood loss per minute of transection time, is there still a significant difference between the two groups? Among 424 consecutive resections performed in Hamburg, the Pringle maneuver was used in 152 of 268 major resections and in 67 of 156 minor resections. In contrast to your study, the average occlusion time was only 23 minutes, reaching from 9 to 45 minutes. Our policy is to obtain perfect inflow and outflow control and then to do a relatively fast transection without using the ultrasonic dissector for transecting the parenchyma. So from there, my next question is: How much of the preparation do you actually perform in the hilum when you do your liver resections?