A Simplified Technique for Hepatic Resection:

The Crush Method

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A new technique of hepatic lobectomy with combined use of hepatic clamp and liver crush clamp is described. It is a simplification of the original finger fracture technique by using instruments instead of fingers for hepatic resection. It provides the unexperienced with a technique of hepatic resection done in the shortest possible time and in an almost bloodless field with safety. Since February 1973 the author has performed 5 hepatic resections with this crush method for primary liver cell carcinoma. The blood transfusion averaged 200 ml and the operation time averaged 1.5 hours. No complication or mortality was encountered and the patients were invariably discharged within 14 days after the operation.

SINCE THE PROPOSAL of the finger fracture technique for hepatic lobectomy in 1954, the feasibility and reliability of this technique have been attested to in 104 cases[1,2] and has proved superior to the conventional "control method." By finger fracture technique, the friable liver tissue is fractured with fingers while isolating the resistant vascular and ductal structures intrahepatically. The cumbersome and potentially dangerous procedure of isolating hepatic artery, portal vein, hepatic duct and hepatic veins outside of the liver in "control method" is thus avoided and the operative procedure is simplified. However, there is some unnecessary bleeding from the resection line which makes the surgeons feel uneasy with the finger fracture technique, even though it takes only 10 to 15 minutes to complete the resection.

To obviate this shortcoming of the finger fracture technique, a special hepatic clamp was designed by the author in 1970. Application of the hepatic clamp prior to finger fracturing of the liver renders hepatic resection possible in an almost bloodless field.[3] Nevertheless, this improved method is still deemed by many as a complicated maneuver. Inserting the fingers into a vascular spongeorgan like the liver and searching the main intrahepatic vascular and ductal structures with fingers certainly cause a feeling of insecurity to the unexperienced who refrain from its wide application. Recently the author further simplified the finger fracture technique by devising a "crush method." Basically, the crush method is similar to the finger fracture technique in principle. The only difference is that instead of fracturing the liver tissue and isolating the unyielding vascular and ductal structure with fingers, a heavy crush clamp is used to crush the liver tissue and expose the vascular and ductal structures under direct vision. This new technique has been applied in 5 cases of primary liver cell carcinoma since February 1973, and has proven the best and most simplified method for hepatic lobectomy. The result and the method are reported in detail.

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Instruments

Specially designed hepatic clamp and liver crush clamp are required. The hepatic clamp (T. Y. Lin's hepatic clamp) has been previously reported in detail.[4] The liver crush clamp is designed to crush liver tissue without damaging the vascular or ductal structures of the liver as shown in Fig. 1B. It is heavily constructed, with a smoothly surfaced lower blade and a upper blade engraved with small shallow longitudinal grooves. The margins of the blades are rounded.

The scissors, though not specific for hepatic resection,

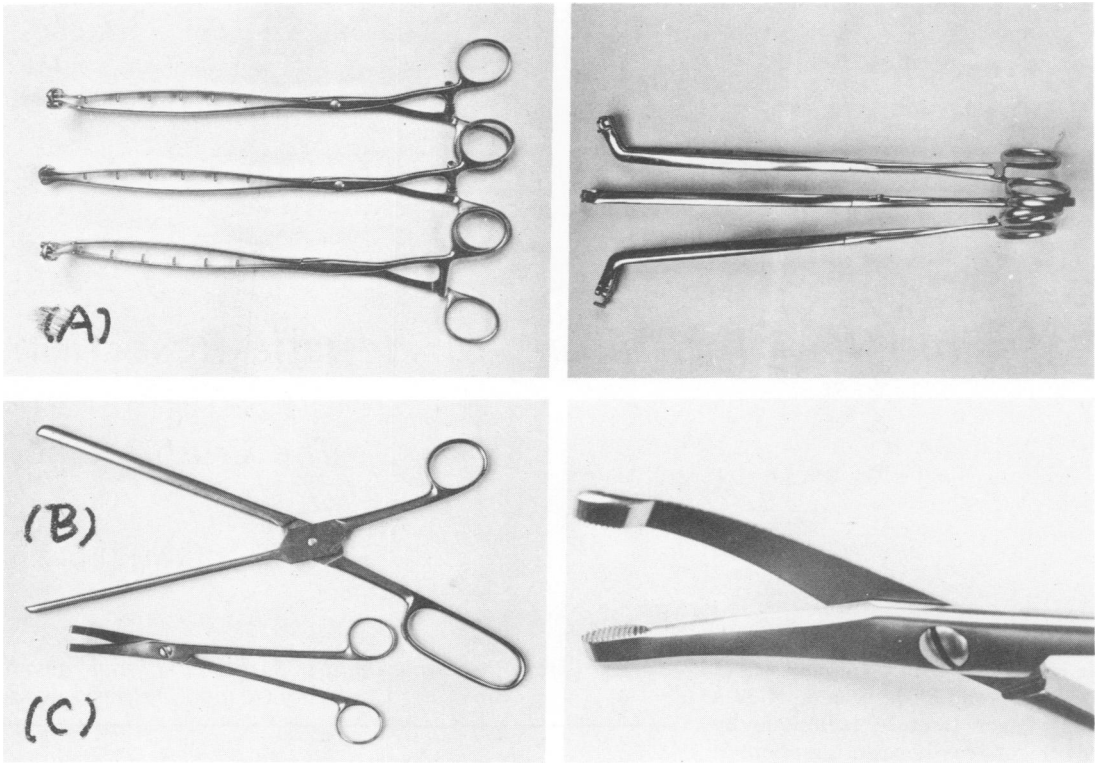

FIG. 1. T. Y. Lin's liver resection instrument. A. Hepatic clamp. B. Hepatic crush clamp. C. Scissors.

are made as shown in Fig. 1C. to serve triple roles as scratcher, guider and cutter.

Operative Technique

Hepatic Lobectomy

The upper abdomen is entered through a curved transverse incision along the costoabdominal line. Thoracotomy and splitting of diaphragm may be added if necessary. After exposing the lesion, the falciform ligament, triangular and the coronary ligaments of the affected lobe are divided and the liver is freed from the

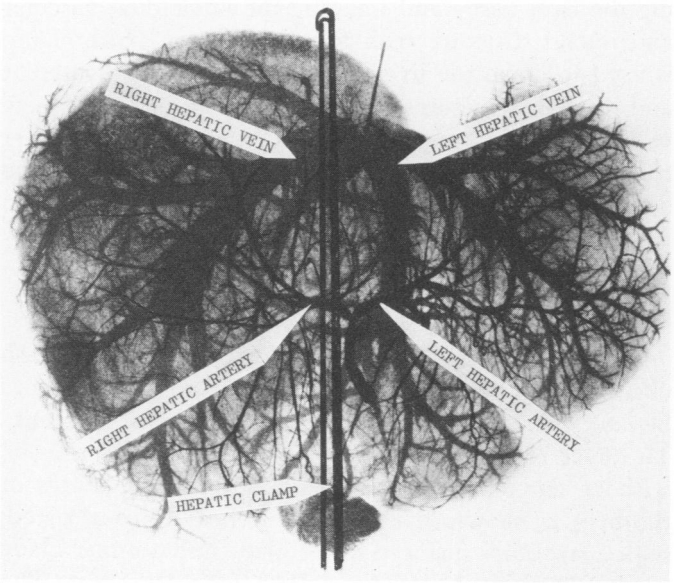

FIG. 2. The direction of hepatic clamp in relation to hepatic artery and hepatic vein in right hepatic lobectomy.

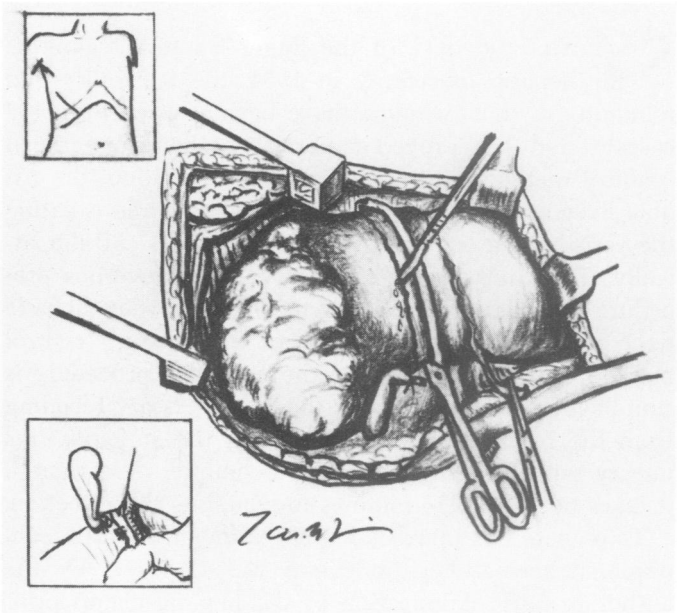

FIG. 3. Using the transected ligamentun teres for traction, the hepatic clamp is placed near the anatomical boundary of both lobes and the Glisson's capsule is now incised at the superior surface about 2.5–3 cm aside from the clamp.

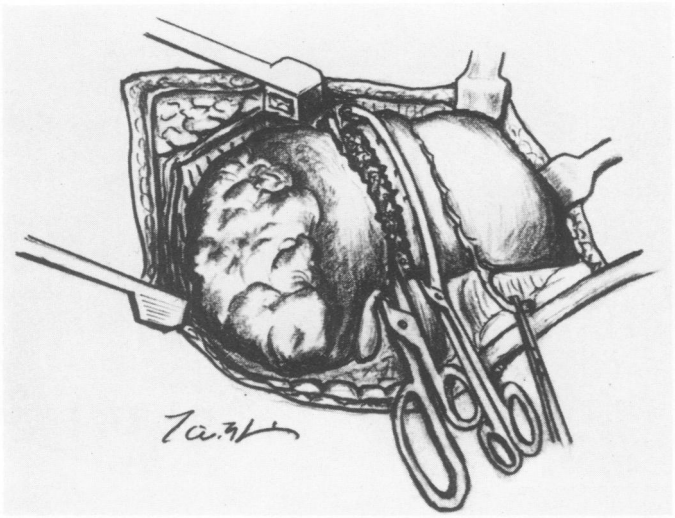

FIG. 4. Crush clamp is applied right on the incision line and thoroughly clamped to crush away the friable parenchymatous tissue.

diaphragm. In case of right hepatic lobectomy, the cystic duct and cystic artery are further cut, leaving the gallbladder attached to the right lobe. The end of the divided round ligament is clamped and used for traction to keep the liver in suitable position for resection. All these are needed before resection, leaving the hepatic artery, portal vein, hepatic duct and hepatic veins unexplored.

Next, the hepatic clamp is tightly applied on the affected lobe at the vicinity of the anatomical boundary of hepatic lobes, with the toothed blade on the superior surface (Figs. 2 and 3).

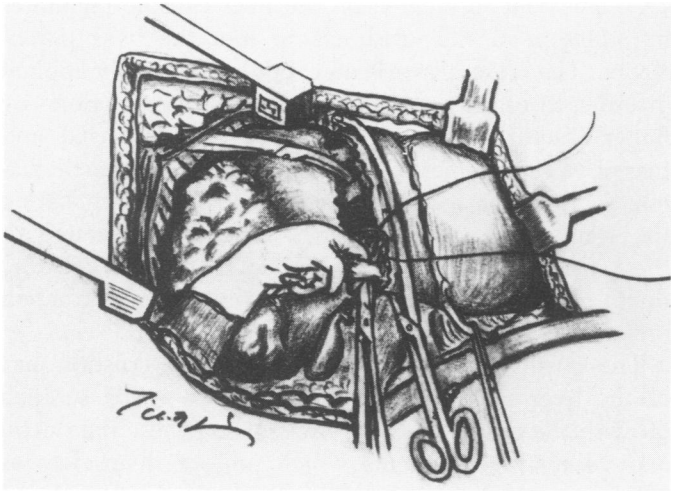

FIG. 5. On release of the crush clamp, the unyielding vascular and ductal structures appear as bridges between the two compartments of the liver. They are further isolated from the destroyed liver tissue with the finger and secured with double ligation followed by division to complete the hepatic lobectomy.

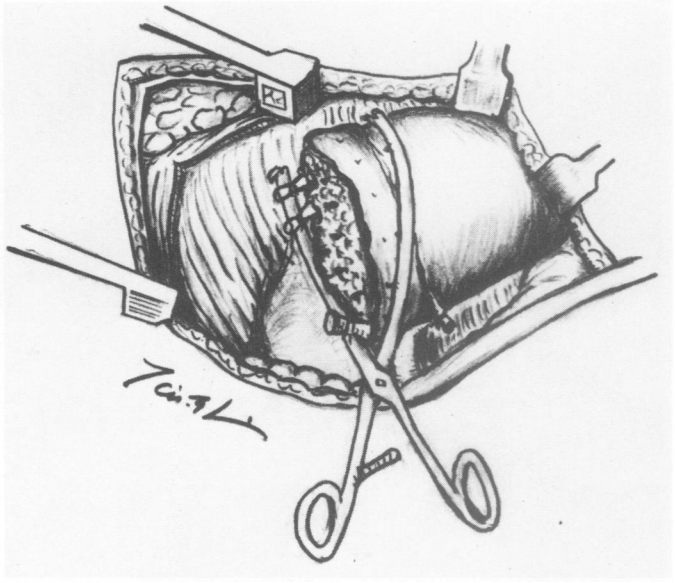

FIG. 6. After partial release of the hepatic clamp, bleeders from the liver parenchyma are suture ligated and then the clamp is removed.

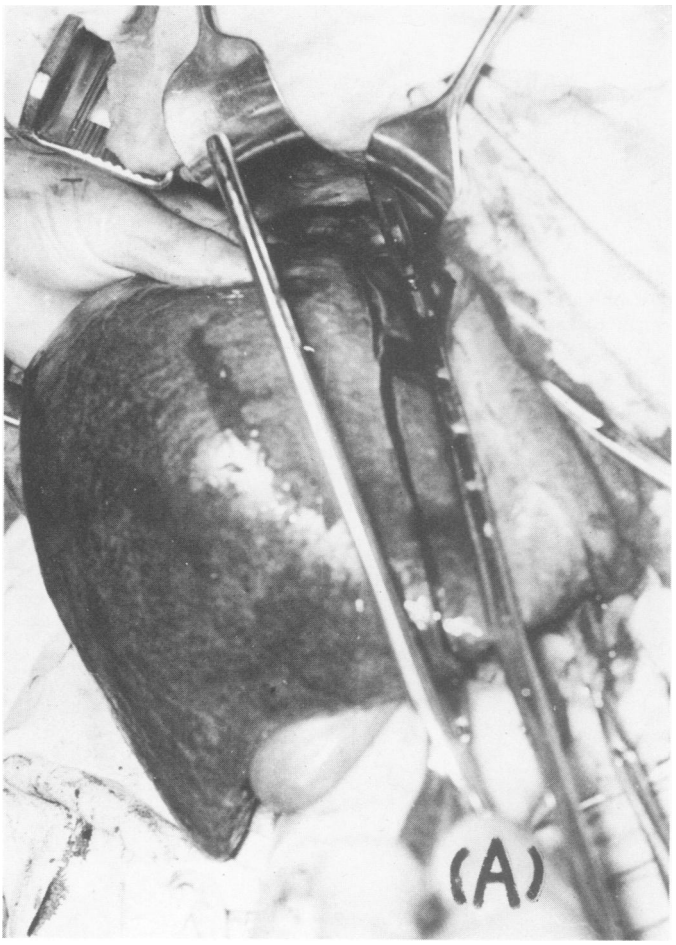

FIG. 7. A. Showing the incision line 2.5 cm aside from the applied hepatic clamp and the crush clamp about to be applied.

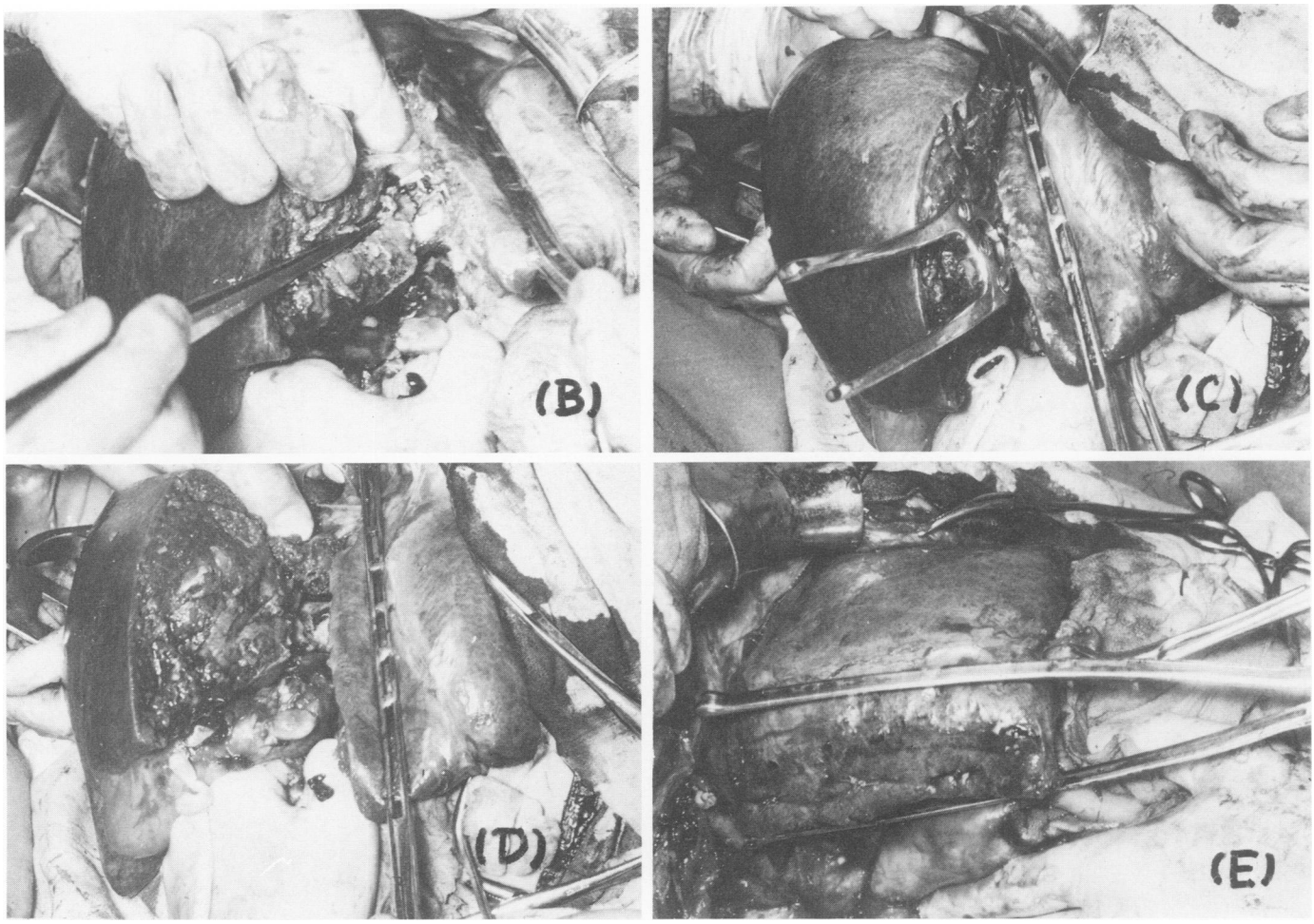

FIG. 7. B. After release of the crush clamp, the right hepatic artery, portal vein branch and right hepatic duct appear as whitish cords. C. Small crush clamp was reapplied to crush the posterior part of the liver which did not completely yield at the initial crushing. D. After thorough crushing, the hepatic vein now appears as a whitish cord at the posterior inferior aspect of the crush surface. E. After securing all of the bleeders by partial release of the hepatic clamp, the clamp is going to be removed.

A section line is created by cutting open the Glisson's capsule at 2.5–3.0 cm apart from the hepatic clamp on the superior hepatic surface of the affected lobe. (Fig. 7A). The rent so created on the liver capsule facilitates introduction of the crush clamp into the liver parenchyma. The crush clamp is now totally and tightly applied in order to crush away the liver tissue as that done by finger fracture (Fig. 4). The clamp is released and reapplied three times to break up all of the parenchymatous tissue. Great caution should be exerted in repeating the clamping and releasing in the same direction at the same plane with gentleness so that the unyielding ductal and vascular structures are not torn by traction or kinking.

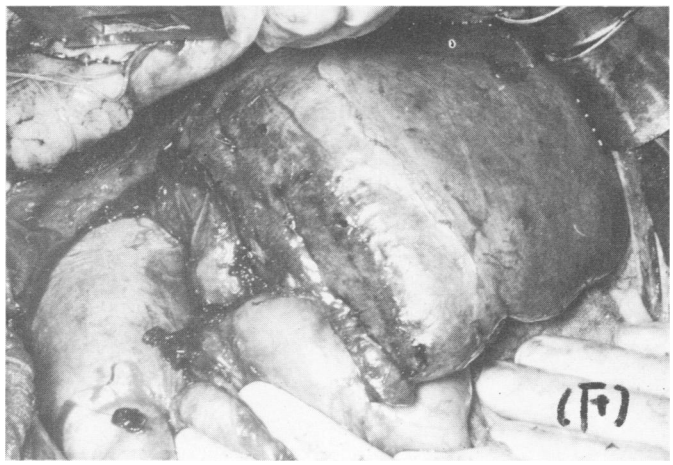

FIG. 7. F. Completion of right hepatic lobectomy.

The crush clamp is then removed. The crushed part of the liver looks like jelly and can be easily scraped off with the tip of T. Y. Lin's scissor to expose the ductal and vascular components which present themselves as whitish cords bridging the two compartments of the liver (Fig. 5). The hepatic artery, portal vein branches and hepatic duct lie anteriorly and the hepatic vein posteriorly at the crushed part of the liver. Smaller vessels and ducts are simply ligated, major ones are

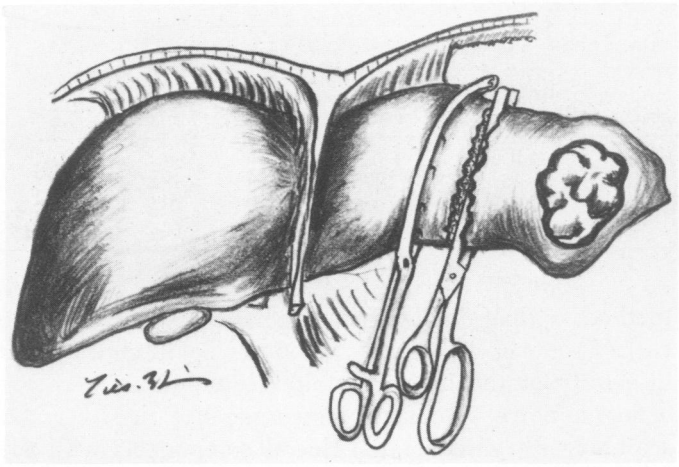

FIG. 8. The hepatic clamp in place. The liver parenchyma is crushed with the crush clamp through the incision on the superior surface of Glisson's capsule.

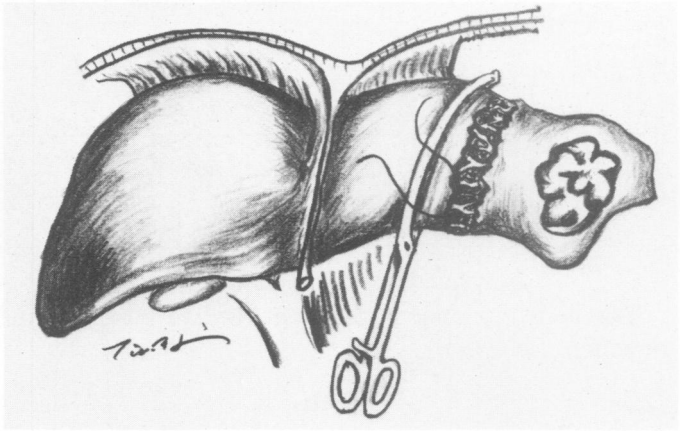

FIG. 9. On release of the crush clamp, the vascular and ductal structures remain as whitish cords bridging the two parts of the liver.

doubly ligated (with one being suture ligature) after securing its isolation with finger and rounding the ligating silk with the tip of the scissors. (Figs. 7B, D). These vascular and ductal components are then divided to detach the affected lobe.

The hepatic clamp is slightly loosened to check bleeders, and if any, they are suture ligated. The hepatic clamp is totally removed after complete hemostasis (Figs. 6, 7E).

The bare surface of the remaining liver is covered with nearly pedicle flap or free flap of omentum.

Partial Resection of the Liver

The hepatic clamp is applied at the healthy part of the affected lobe. A section line is created by cutting open the Glisson's capsule 2.0–2.5 cm apart from the hepatic clamp. The crush clamp is applied on the section line and crushes the liver tissue with force (Fig. 8).

On release of the crush clamp, the unyielding vascular and ductal components will appear as cord-like bridges connecting the two parts of the liver. These cord-like bridges are individually ligated and divided (Fig. 9).

The cut surface of the liver is secured of bleeding or bile leakage with interrupted mattress sutures.

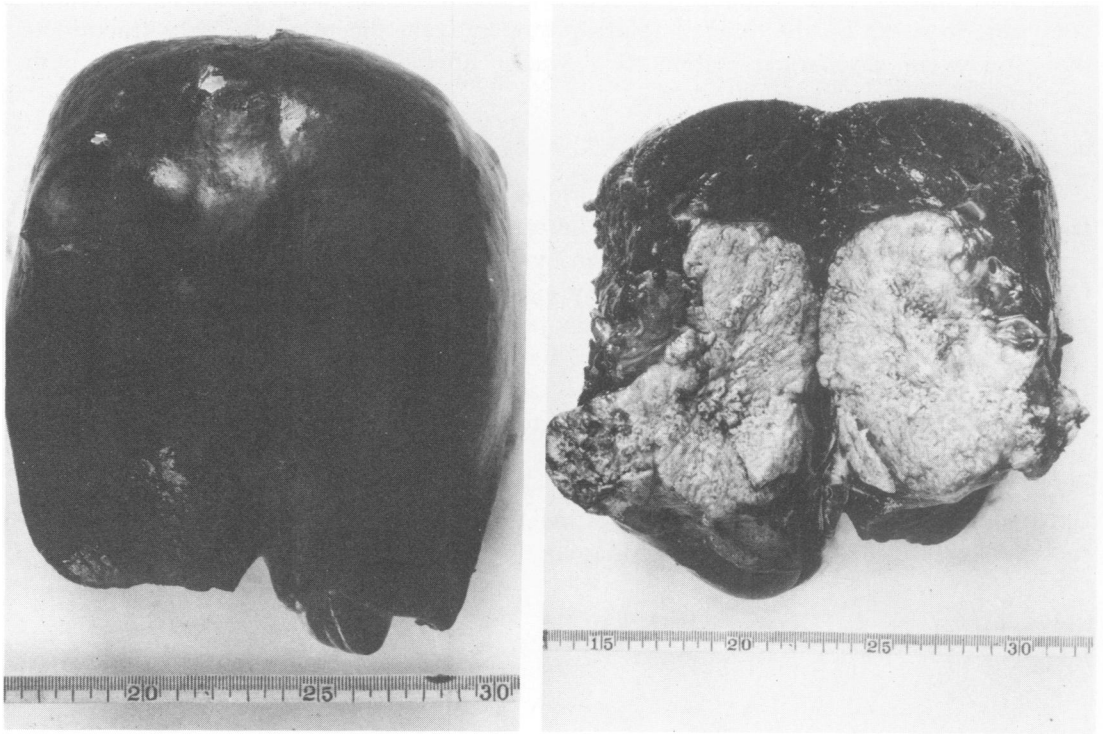

FIG. 10. Operative specimen showing malignant hepatoma.

TABLE 1. *Results of Author's Three Series of Hepatic Lobectomies*

Technique	Total Cases	Op. Time: Skin-to-skin	Op. Time: Liver Resection	Blood Transfusion	Operative Mortality
		(hrs)	(min)	(cc)	
Original Finger Fracture	104	2–3	10–15	1000–3000	3.8%
Finger Fracture + Hepatic Clamp	12	1.5–2.5	10	100–200	0%
Crush Method + Hepatic Clamp	5	1–2	5–8	100–200	0%

The hepatic clamp is then removed to complete the resection.

Results

Since February 1973, 5 cases of primary liver cell carcinoma were treated by hepatic lobectomy with this crush method. Of the 5 cases, 3 received right hepatic lobectomy and 2 had left hepatic lobectomy. One case that had undergone left lobectomy was associated with liver cirrhosis. The age varied from 32 years to 48 years and 3 were males and 2 females. The operation time needed with this method was about 1–1½ hours for skin to skin, and only about 5–8 minutes for hepatic resection per se. Blood transfusion during the operation amounted to less than 100 ml in all but two cases in which additional transfusion was needed for oozing in separating adherent mesocolon, colon, stomach and retroperitoneum from the tumor after completion of the hepatic resection. The resected hepatoma were all of massive type, weighing up to 2300 gm at maximum and some showed central necrosis (Fig. 10). Histologically they all proved to be liver cell carcinoma. None of the cases had postoperative complication and the patients were able to sit up by the third or fourth postoperative day and were discharged within two weeks after operation.

Discussion

The crush method is similar to the original finger fracture technique in principle and in shortening the operation time needed for hepatic resection by avoiding isolation and division of the hepatic artery, portal vein branches and hepatic duct at the hepatic hilum and hepatic veins underneath the diaphragm as that done in the "control method." The crush method is actually a simplified method of the original finger fracture technique and bears many advantages over the latter in that: 1) since a hepatic clamp is being applied at the anatomical boundary of the liver lobes before crushing the liver tissue, the fear of bleeding in the crush method is thus obviated and hepatic resection can be carried out in an almost bloodless field; and 2) the insecurity of the finger fracture technique in inserting a finger into a vascular spongeorgan like the liver and searching for vascular and ductal components with the inserted fingers is avoided in the crush method which presents the vascular and ductal structures to be divided readily under direct vision after crushing the liver tissue with crush clamp. The other benefit of the crush is that the presence of liver cirrhosis or fibrosis, which defies finger fracturing, will yield to the crush clamp.

The result of three series of patients treated with original finger fracture technique (104 cases between March 1954 and November 1970), with the hepatic clamp and finger fracture technique (12 cases between December 1970 and January 1973), and with the crush method and hepatic clamp are compared. The superiority of the crush method over the other two is evident from Table 1.

The only shortcoming of the crush method is that when the tumor extensively involves a whole hepatic lobe or more, there may be no room for applying either the hepatic clamp or crush clamp. In such instance, the original finger fracture technique may be resorted to for hepatic resection with the help of rapid transfusion with pumping system and transient occlusion of hepatic inflows at the hilum with the Satinsky vascular clamp.

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