

REGENERATION OF THE LIVER AFTER HEPATECTOMY

Frank H. DeLand and Henry N. Wagner, Jr.

The Johns Hopkins Medical Institutions, Baltimore, Maryland

Clinical findings. A 30-year-old female was admitted to the hospital complaining of frequent indigestion and eructation for 3–4 months with associated anorexia for 3 weeks. One week before hospitalization she noted a moderately severe constant pain in the right upper and lower quadrants of the abdomen. The pain could be relieved by aspirin and was aggravated by exertion but seemed unrelated to eating or defecation. A few days before admission she experienced urinary frequency, chills, fever and vomiting. She had lost 12 lb since the onset of symptoms. There was no history of alcoholic intake or exposure to hepatotoxic drugs or chemicals. The patient had always lived in Baltimore and had never traveled outside of the United States.

On examination there was tenderness to palpation in each costovertebral angle which was worse on the right. There was a large, nontender, knobby mass in the abdomen which was thought to involve the liver because it moved with the liver during respiration. The liver extended 13 cm below the right costal margin.

Ancillary findings. The patient had a leucocytosis of 33,000 with a left shift, proteinuria and Grade IV pyuria. An intravenous pyelogram was within normal limits. The serum alkaline phosphatase was 14.3 King Armstrong Units, the bilirubin was 1.3 mg%, the glutamic oxaloacetic transaminase was 61 units, the albumin was 2.6 gm% and the globulin was 3.8 gm%. Barium enema, x-ray bone survey and bone-marrow examination were within normal limits.

Liver scan. We made a radioisotope scan of the liver after injecting 2 mc of ^{113m}In -colloid intravenously (1). In the anterior view (Fig. 1A) the liver was markedly enlarged, measuring 23×25 cm. An area of decreased activity 12–13 cm in diameter occupied most of the middle and lower thirds of the right lobe. The right lateral view (Fig. 1B) showed a defect in the lower portion of the

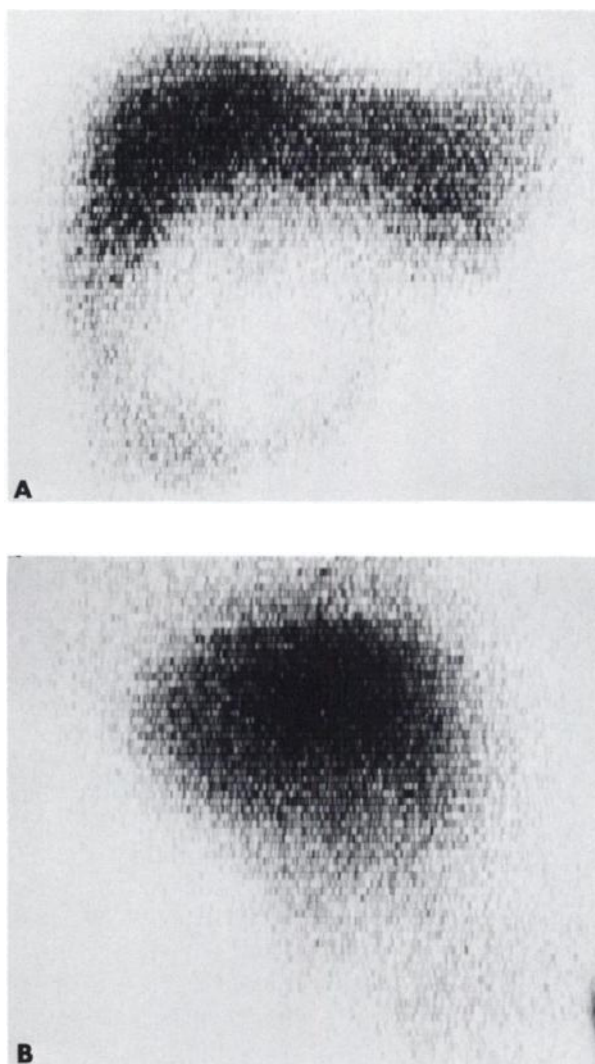


FIG. 1. A is anterior scan of liver before surgery. There is marked enlargement of right lobe which contains extensive area of decreased radioactivity. B is lateral view of liver before surgery. Radioactivity is decreased in inferior half of right lobe.

Received Feb. 14, 1968; revision accepted April 19, 1968.
For reprints contact: F. H. DeLand, Dept. Radiological Science, The Johns Hopkins Univ., School of Hygiene and Public Health, 615 No. Wolfe St., Baltimore, Md., 21205.

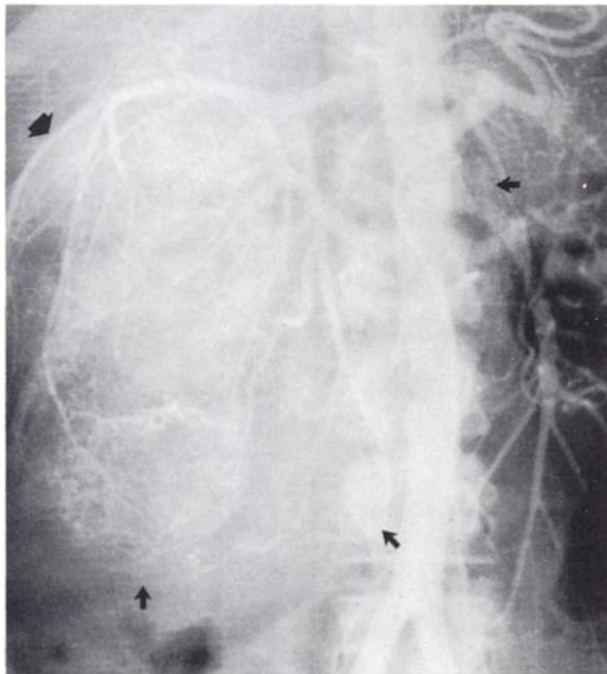


FIG. 2. In angiogram of liver made after injection of contrast material into celiac artery, unusual vessels, outlined by arrows, occur in same position as defect on scan in Fig. 1.

right lobe. On the angiogram of the celiac and superior mesenteric arteries (Fig. 2), irregular vascular channels occurred in the same position as the defect on the scan and the right hepatic artery was displaced to the right (large arrow). A pulmonary scan and chest x-ray did not suggest involvement of the right lung.

Hospital course. The patient underwent a laparotomy on the thirteenth hospital day. The right and quadrate lobes of the liver contained a multinodular, yellowish-brown mass $15 \times 14 \times 11$ cm which was demarcated sharply from the liver which appeared normal (Fig. 3). The right, quadrate and caudate lobes of the liver were resected. The margin of the resection extended beyond the mass. The pathological finding was hepatocellular carcinoma. The patient had a fever of $100\text{--}102^\circ\text{F}$ for about 12 days after operation, thought to be due to atelectasis. One week after surgery the blood ammonia increased to $159 \mu\text{g}\%$, serum bilirubin to $10.0 \text{ mg}\%$ and serum alkaline phosphatase to 17.5 King Armstrong Units. After 3 weeks the blood ammonia was $65 \text{ mg}\%$, the serum bilirubin was $3.5 \text{ mg}\%$, the serum alkaline phosphatase was 15 King Armstrong Units, the albumin was $4.8 \text{ gm}\%$ and the globulin was $3.4 \text{ gm}\%$.

We repeated the liver scan on the 19th postoperative day (Fig. 4). On the anterior view the liver had become rhomboidal in shape and measured

about 17×19 cm. Most of the liver was to the left of midline and below the costal margin. The patient was discharged on the 31st postoperative day feeling well and eating without difficulty. The liver scan was repeated on the 37th postoperative day and was identical to that on the 19th postoperative day (Fig. 5).

DISCUSSION

Improved surgical technique has led to an increase in surgery of the liver (2,3). Simultaneously liver scanning has been used more and more as a diagnostic aid (4,5). The present case illustrates how liver scanning can be used to provide objective evidence of the size and structure of the liver after partial hepatectomy.

In the patient described in this report there was evidence within 19 days of considerable regeneration in the liver image on the scan. This is consistent with previous experience in experimental animals (6).

One of the earliest experimental investigations of liver regeneration after partial hepatectomy was that of Ponfick in the late nineteenth century (7). He found that the liver of rabbits would regenerate to approximately its original weight even after as much as 90% had been resected. Using radioactive colloidal gold, Baker *et al* (8) were able to measure the exact amount of liver resected and the degree of regeneration. The results were similar to those in the patient of this report. After 70% of the liver had been removed in dogs, regeneration was nearly complete within 18 days. Other studies in animals indicated that complete regeneration occurred within 4–8 weeks (9,10).

McDermott *et al* (11) published one of the first reports on the use of liver scanning which was to evaluate regeneration of the liver in man after he-

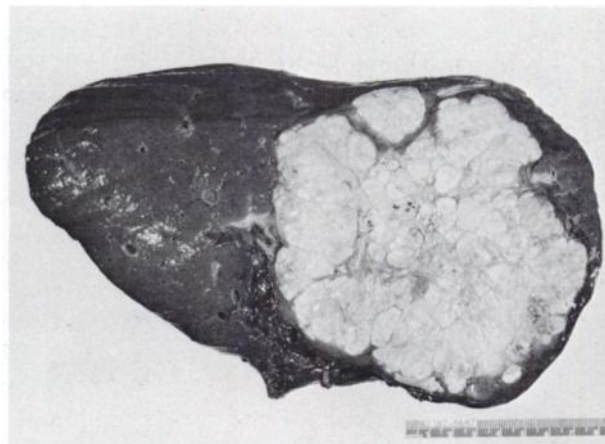


FIG. 3. Cross section of liver specimen removed at surgery.

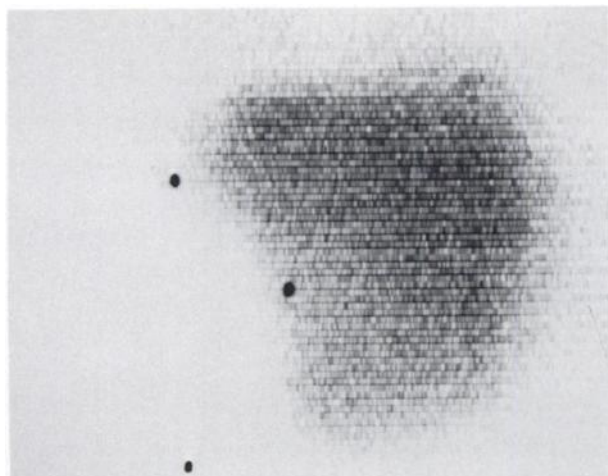


FIG. 4. In anterior scan of liver 19 days following surgery, considerable regeneration of left lobe can be seen. Black dot in center is in midline of the body.

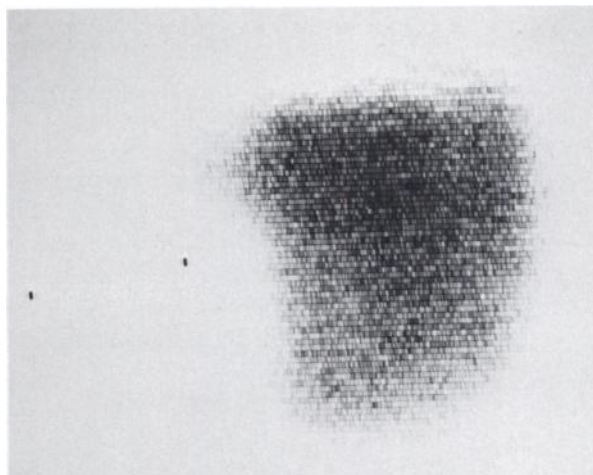


FIG. 5. Anterior scan of liver 37 days following surgery. Size and configuration of organ are identical to that seen 19 days after operation.

hepatectomy. Previously little information could be obtained on the extent or anatomical location of the regeneration. With scanning, however, it has been found that after resection of the right, quadrate and caudate lobes the left lobe regenerates with a configuration closely resembling a rectangular solid or ellipse (11-16). After regeneration the liver may be centrally located in the abdomen or extend into the right upper quadrant. If only the left lobe is resected, the regeneration may mimic the normal liver in shape (13). This case illustrates a diagnostic value of radioisotope scanning of the liver.

REFERENCES

1. GOODWIN, D. A., STERN, H. S., WAGNER, H. N., JR. AND KRAMER, H. H.: A new radiopharmaceutical for liver scanning. *Nucleonics* 24:No. 11; 65, 1966.
2. LORTAT-JACOB, J. L. AND ROBERT, N. G.: Hepatectomie droite reglee. *Presse Med.* 60:549, 1952.
3. QUATTLEBAUM, J. K.: Massive resection of the liver. *Ann. Surg.* 137:787, 1953.
4. MCAFEE, J. G., AUSE, R. G. AND WAGNER, H. N., JR.: Diagnostic value of scintillation scanning of the liver. *AMA Arch. Internal Med.* 116:95, 1965.
5. WHANG, K. S., FISH, M. B. AND POLLYCOVE, M.: Evaluation of hepatic photoscanning with radioactive colloidal gold. *J. Nucl. Med.* 6:494, 1965.
6. BUCHER, N. L. R.: Regeneration of mammalian liver. *Intern. Rev. Cytol.* 15:245, 1963.
7. PONFICK, E.: Ueber leber-resection und leberrecreation. *Verh. Dtsch. Ges. Chir.* 19:28, 1890.
8. BAKER, R. B., MIGITA, T. AND WAGNER, H. N., JR.: A quantitative method of measuring liver regeneration in the dog. *J. Surg. Res.* 7:578, 1967.
9. FISHBACK, F. C.: A morphologic study of regeneration of the liver after partial removal. *Arch. Pathol.* 7:955, 1929.
10. MANN, F. C.: The partial circulation and restoration of the liver after partial removal. *Surgery* 8:225, 1940.
11. McDERMOTT, W. V., JR., GREENBERGER, N. J., ISSELBACHER, K. J. AND WEBER, A. L.: Major hepatic resection: diagnostic techniques and metabolic problems. *Surgery* 54:56, 1963.
12. MONACO, A. P., HALGRIMSSON, J. AND McDERMOTT, W. V.: Multiple adenoma (Hamartoma of the liver) treated by subtotal 90% resection. *Ann. Surg.* 159:513, 1964.
13. PARKER, J. J. AND SIEMSEN, J. K.: Liver regeneration following hepatectomy evaluated by scintillation scanning. *Radiology* 88:342, 1967.
14. LIN, T.-Y. AND CHEN, C.-C.: Metabolic function and regeneration of cirrhotic and non-cirrhotic livers after hepatic lobectomy in man. *Ann. Surg.* 162:959, 1965.
15. BREMER, E. H., BACOS, J., AUGUSTIN, G. AND SABTINE, D.: Regeneration of the liver after major hepatic resection. *Med. Ann. District Columbia* 35:115, 1966.
16. McDERMOTT, W. V. AND OTTINGER, L. W.: Elective hepatic resection. *Am. J. Surg.* 112:376, 1966.