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A NEW METHOD FOR ONE-STAGE HEPATECTOMY FOR DOGS

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ONE of the traditional methods for investigation of the function of various viscera has been by analysis of the consequences of removal of the organ or organs in question. Although this has generally been a simple matter technically, the extirpative approach to the problem of hepatic function in the dog has proved to be unusually troublesome. The anatomic basis for this is the close approximation of the subdiaphragmatic inferior vena cava to the liver. This relationship is so intimate that a segment of vena cava is resected in all popular methods of total hepatectomy and it is commonly thought that removal of the liver is not otherwise possible.[9] Employing this principle, it is then necessary to provide a mechanism for both portal and inferior caval venous return. This has been done with multiple-staged procedures designed to initially promote collateral venous return,[6, 8, 9] or in single-stage operations by the interposition of glass or plastic cannulae into the resected caval segment with drainage of the portal system into the vena cava more inferiorly.[2, 7, 10]

All presently employed methods of hepatectomy have serious disadvantages. The operative mortality is high. Multiple-staged methods require long intervals between operations, the final operation is bloody due to the presence of adhesions, and the state of caval and portal drainage is likely to be inadequate in the preparation finally obtained. The use of prosthetic cannulae in single-stage techniques introduces other hazards of air embolus, hemorrhage and clot formation, or defibrination in the cannula.

In this laboratory, considerable experience has accumulated with a single-stage total hepatectomy in which no prosthetic devices are used and in which the inferior vena cava is preserved. The operation has a mortality of less than 10 per cent. Maximum survival time compares favorably with any other method.

METHODS

Sixty mongrel dogs, weighing 10 to 30 kilograms were used. Until the day of surgery the animals were on standard kennel rations. In 56 cases, sodium pentobarbital anesthesia was used because of the requirements of the experiment for which hepatectomy was done. In 4 animals used for study of maximum

Aided by Grant No. A-3176 from the United States Public Health Service, National Institutes of Health, Bethesda, Md.

Received for publication July 20, 1959.

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survival time, ether anesthesia by face mask was employed. Endotracheal intubation was not necessary since the pleural cavity was never entered. Postoperatively, a glucose infusion was given at the rate of 0.3 to 1 Gm. per kilogram per hour. Isotonic saline was given at the rate of 4 to 8 c.c. per kilogram per hour. The intravenous infusions were delivered with a constant inferior pump to the dogs anesthetized with sodium pentobarbital, and intermittently with a syringe to the animals operated upon under ether anesthesia. In about half of the animals, blood transfusions of 200 to 300 c.c. were given, either several hours before operation or at the time of surgery. The animals studied for maximum survival were allowed complete freedom of a large room. Aside from the intravenous infusions, and one postoperative dose of penicillin, no other therapy was given. Arterial and venous pressures were studied with inductance manometers which had a frequency response in excess of 30 cycles per second. The operation was done under clean rather than sterile conditions.

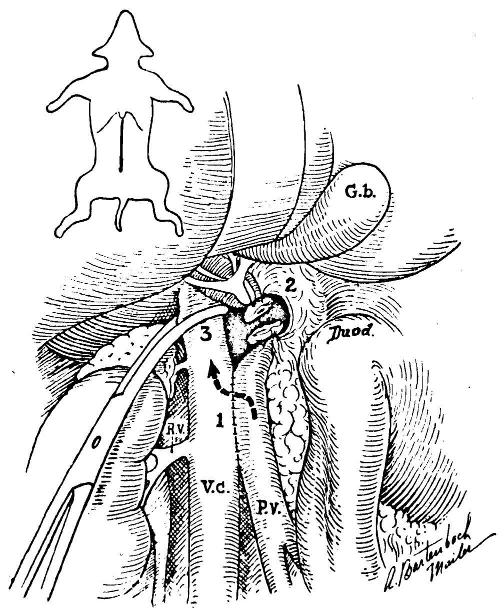

Fig. 1.—Total hepatectomy in dog. Portacaval anastomosis has been completed, and the portal triad ligated and divided. A noncrushing clamp has been applied to the inferior vena cava above the entrance of the adrenal veins.

DESCRIPTION OF TECHNIQUE

The abdomen is entered through a long upper midline incision (Fig. 1, inset). The inferior vena cava is looped with an umbilical tape, above the entrance of the adrenal veins, to facilitate subsequent manipulation. The portal triad is similarly encircled. A long (at least 1 cm.) side-to-side portacaval anastomosis is then performed, using modern vascular techniques, as previously described.[5, 11] Next the ligatures around the portal triad are tied, and the triad is cut (Fig. 1). The inferior vena cava is then occluded with a noncrushing clamp above the level of the adrenal veins (Fig. 1).

The hand is next placed over the dome of the liver and with gentle downward traction the mesenteries connecting the liver lobes to the diaphragm are cut. When this is completed a finger can be insinuated around the cava in the space between the diaphragm and the liver. The liver is then retracted inferiorly, and a noncrushing clamp is placed across the inferior vena cava between the dome of the liver and diaphragm (Fig. 2). The liver has now been completely devascularized, and the short segment of inferior vena cava into which the hepatic veins empty is trapped between the two noncrushing clamps.

It is now possible, in a bloodless field, to dissect the liver from the inferior vena cava. This is begun superiorly (Fig. 2). Viewed from below, the largest hepatic vein is located at 2 o'clock and is the first to be encountered (Fig. 2). It is often easiest to cut boldly into this vessel and complete its isolation from within the lumen. The liver is then peeled inferiorly using sharp and blunt dissection, and as other hepatic veins are encountered they are isolated and ligated. Between 6 and 8 hepatic veins are found in all. After the last vein is tied, a flimsy vein of gastrohepatic omentum is the only remaining intact structure. This is ligated and the specimen removed.

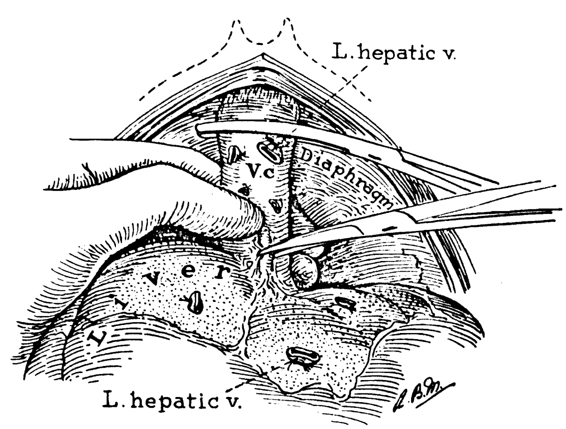

Fig. 2.—After occlusion of the suprahepatic vena cava the liver is removed; hepatic veins are ligated as encountered.

The inferior Pott's clamp is then removed. If any bleeding areas are encountered on the inferior vena cava, these are repaired with arterial silk or ligated. When hemostasis is complete the superior clamp is removed, and portal and inferior caval venous drainage is re-established (Fig. 3).

The operating time, from skin to skin, ranges from 60 to 90 minutes. The measured blood loss is ordinarily between 50 and 200 c.c.

RESULTS

Operative Mortality.—Hepatectomy was attempted on 60 dogs. Two animals died of hemorrhage during the portacaval anastomosis, and a third succumbed 2 hours postoperatively from intra-abdominal bleeding. All other animals were used for study. The survival then in terms of the achievement of a useful preparation was 95 per cent. It is worth emphasizing that the only dangerous part of the operation is the preliminary portacaval anastomosis. No animal died during the actual removal of the liver.

Postoperative Behavior.—All animals operated upon under ether anesthesia woke promptly and appeared to be entirely normal. At varying times, from 15 to 36 hours, coma developed which was no longer responsive to sugar administration. All dogs studied longer than 24 hours manifested secondary bleeding, either from the incision, or within the abdomen, or both. Until this development the animals urinated frequently and had slow pulses. After the onset of the bleeding tendency, anuria and profound tachycardia occurred and were followed within a few hours by death.

Maximum Survival Time.—The 4 animals studied for maximum survival lived 17, 29, 32, and 42 hours for an average of 30 hours.

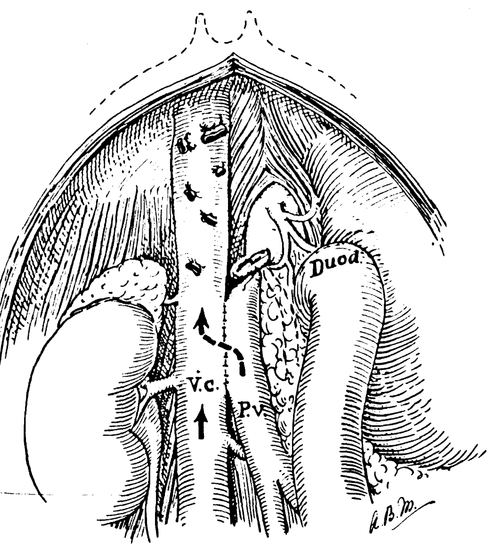

Fig. 3.—Operative field after completion of hepatectomy.

The Effect of the Operation on the Splanchnic and Systemic Circulation.—During the operation there is only one time when the circulatory dynamics of the portal vein and inferior vena cava are not essentially normal. This is during the 15 or 20 minutes while the liver is actually being removed, at which time the inferior vena cava is occluded both above and below the liver. Since at this stage the portal vein has been drained into the vena cava more inferiorly, the portal and venous systems have been converted into a confluent venous pool, and there is concomitant obstruction of the splanchnic venous return.

Experiments were conducted in 3 animals to study the immediate effect of this occlusion on vascular pressures. Shown in Fig. 4 are the changes in the aortic blood pressure and the inferior vena caval pressure in a representative experiment. Since the portacaval systems are in wide communication through the shunt, the latter may also be considered a portal pressure. In the case shown, a fall in arterial pressure occurred to 80 mm. Hg systolic, coincident with a rise in the portacaval pressure to 350 mm. saline. Once established, the vascular pressures remain relatively stable until the caval clamps are released, following which there is prompt restoration of the pre-existing hemodynamic state (Fig. 4).

Although it was ordinarily necessary to obstruct the portacaval system for only 15 or 20 minutes, it was desirable to know how long this occlusion could be maintained with survival. In 5 dogs obstruction was imposed for one hour. In all animals there was prompt recovery after the clamps were removed.

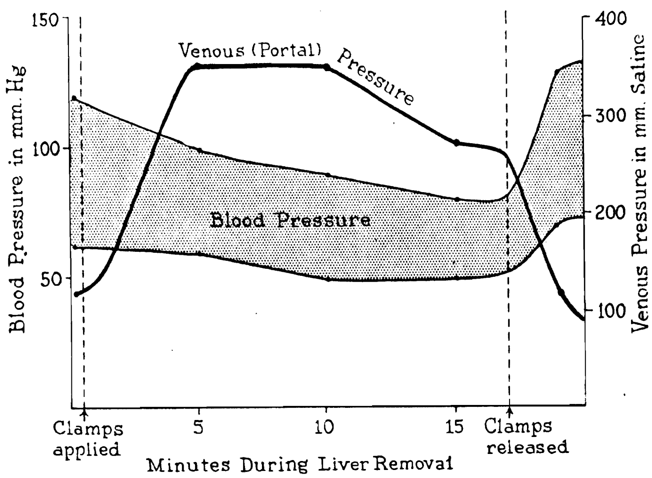

Fig. 4.—Pressures in the arterial and portacaval systems during hepatectomy. See text for explanation.

Autopsy Findings.—Autopsy was performed on most of the animals in this series and on all dogs studied for maximum survival. Thrombosis of the anastomosis, portal vein, or inferior vena cava was not found in any case. In dogs followed less than 20 hours, relatively small amounts of blood-stained fluid were found in the abdomen. Animals followed for longer than this had large amounts of nonclotted blood in the abdomen—sometimes as much as 1,000 c.c. The bowel was grossly normal in all cases, and histologic sections made as late as 42 hours postoperatively were normal (Fig. 5).

DISCUSSION

The described method represents a radical departure from the usual methods of hepatectomy, all of which resect a segment of the inferior vena cava. The only report in which preservation of the inferior vena cava has been described was that of Frank and Jacob.[3] These authors first performed an end-to-side portacaval shunt (necessitating temporary complete occlusion of the portal vein). They then meticulously dissected and ligated the hepatic veins. Because this was not done in a bloodless field, the operation was tedious (3 to 5 hours) and bloody (requiring massive transfusion). Although 3 dogs survived surgery, the authors recommended that their method not be substituted for the conventional techniques of hepatectomy.

The order in which the technical steps are carried out with the present method deserves further comment. It has been known for a long time that complete occlusion of the portal vein can be done safely in dogs for only a few minutes.[1] Acute occlusion of the inferior vena cava above the renal veins, although eventually fatal, can be tolerated for many hours.[12, 14] The difference in response to acute ligation in the two systems is apparently due to a greater capacity of the occluded inferior vena cava to suddenly utilize collateral channels. With the present method the portal and caval systems are first brought into communication through the anastomosis and when the central drainage of both vascular beds is concommitantly occluded, all collaterals are available to either system. The protective effect of this method was shown in the present study, in which it was shown that combined portacaval obstruction could be tolerated for much longer periods (up to 2 hours) than portal obstruction alone.

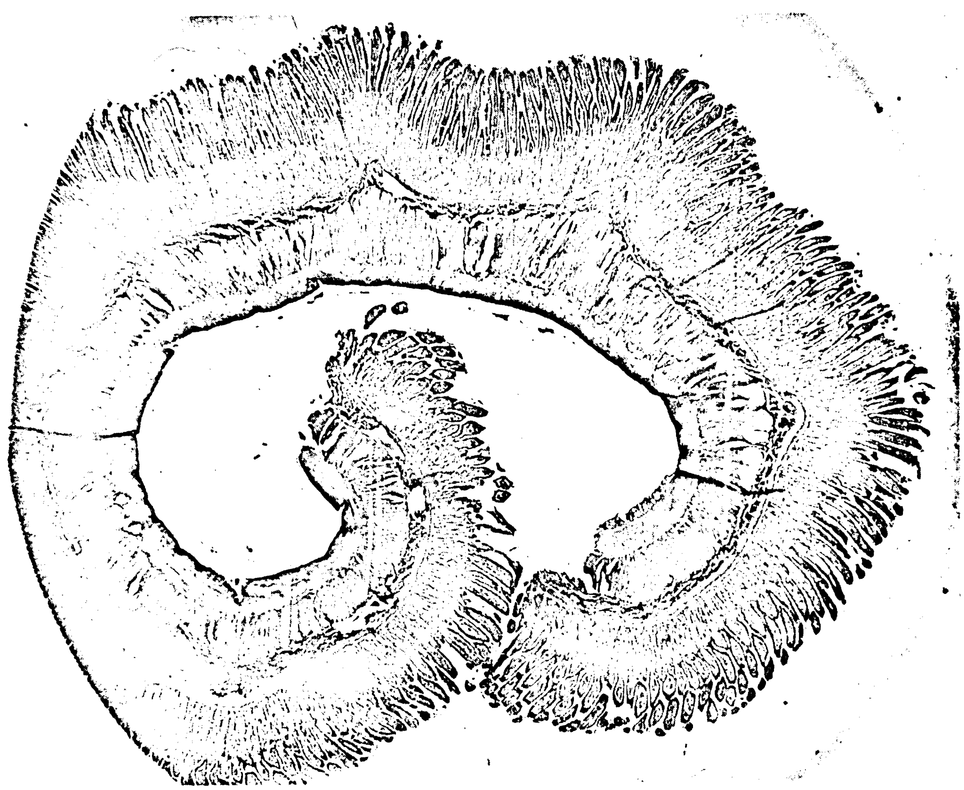

Fig. 5.—Photomicrograph of intestine from dog which survived 42 hours after hepatectomy.

The surgical proficiency necessary to perform this operation is no greater than in other techniques of hepatectomy. The only step that requires unusual care is the formation of the portacaval anastomosis. Because of the elimination of many objectionable features of other methods, this has proved to be for us the most satisfactory method of total hepatectomy.

SUMMARY

A method is described for one-stage complete hepatectomy in dogs with preservation of the inferior vena cava. The method can be done rapidly with minimal blood loss and has a low operative mortality. The maximum survival time compares favorably with other methods of hepatectomy.

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