Experimental Ascites: *

V. Production of Hepatic Outflow Block and Ascites with a Hepatic Vein Choker

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MUCH EVIDENCE indicates that hepatic venous outflow obstruction plays an important role in the pathogenesis of cirrhotic ascites in man.[2, 4, 9] Efforts to decompress the obstructed hepatic vascular bed by the use of various surgical procedures, such as portacaval shunts, have received considerable recent attention.[1, 5, 6, 8, 9] In order to investigate the hemodynamic and metabolic aspects of ascites, an experimental preparation which resembles the human disease is required. It is essential that the production of hepatic outflow block and ascites in the experimental model be accomplished without significantly altering the pressure or blood flow in the inferior vena cava.

In a previous report,[7] a method was described for producing hepatic venous outflow obstruction and persistent, massive ascites by directly ligating the hepatic veins. The technic consisted of ligation and division of all hepatic veins except the large superior hepatic vein, which was partially occluded by a fiberglas ligature. The extent of constriction of the superior hepatic vein was governed by the magnitude of elevation of the portal venous pressure.

In the present study a refinement of the

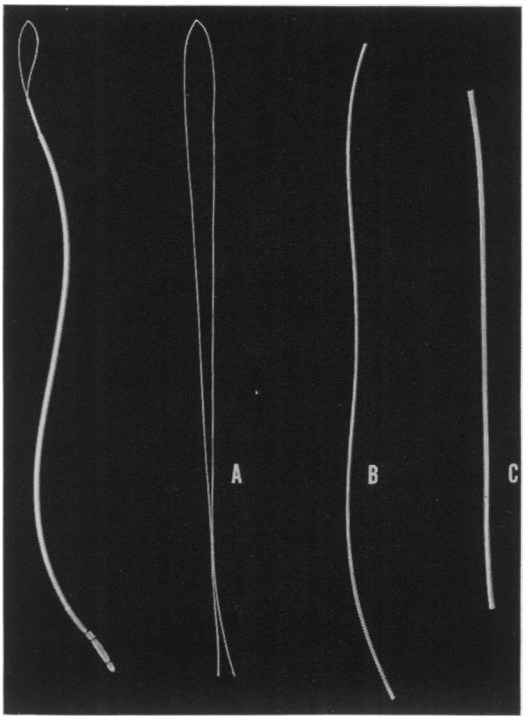

FIG. 1. The superior hepatic vein choker and its components. Inner loop (A) of No. 10 soft polyethylene is passed around superior hepatic vein and then both ends are threaded through middle sheath (B) which is made of No. 190 firm polyethylene. Finally, middle sheath is threaded through outer sheath (C) of No. 280 firm polyethylene, and inner loop and middle sheath are fixed to each other with ligatures so that they will slide as one unit in outer sheath.

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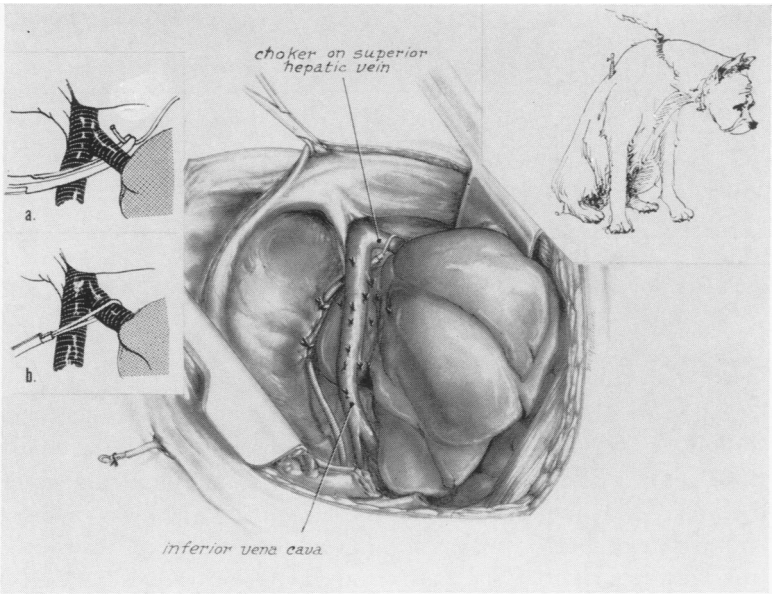

FIG. 2. Insertion of a polyethylene choker around the superior hepatic vein after all other hepatic veins have been ligated and divided. The inner loop of the choker is passed around the superior hepatic vein (insert a.) after which the other parts of the choker are assembled (insert b.). The choker is then passed behind the inferior vena cava, anchored to the diaphragm and posterior body wall, and withdrawn from the peritoneal cavity through a stab wound in the right flank. Finally (not shown), the choker is buried in the subcutaneous tissues.

previously described method was developed which made possible the gradual production of hepatic outflow block and massive ascites by an externally controlled choker around the superior hepatic vein. A description of this modification and the results obtained in 37 dogs form the basis for this report.

Materials and Methods

Operative Procedure. A detailed description of the operative technic for hepatic vein ligation was presented in a previous report.[7] Briefly, the liver was approached through a right thoraco-abdominal incision and the vena cava tunnel within the liver was opened by dividing the thin bridge of hepatic tissue covering the posterior surface of the vena cava. Then the vena cava was extracted from the tunnel by blunt dissection and, in so doing, one after another of the hepatic veins was exposed, ligated and divided until only the superior hepatic vein remained intact. At this point the procedure was modified. The fiberglas ligature previously used to constrict the superior hepatic vein was abandoned and a polyethylene choker was substituted. The choker was similar to the one described by Hume and Nelson[3] for constriction of the adrenal vein and consisted of an inner loop of soft No. 10 polyethylene, a middle sheath of firm No. 190 polyethylene and an outer sheath of firm No. 280 polyethylene †† (Fig. 1). The choker was assembled during the operative procedure. After the inner loop was passed loosely around the superior hepatic vein, its ends were threaded through the middle sheath which, in turn, was threaded through the outer sheath. The inner loop and middle sheath were then fixed to each other with

TABLE 1. *Incidence and Volume of Ascites and Number of Times the Superior Hepatic Vein Choker was Tightened to Produce Ascites in 37 Dogs*

	Mean	Range
Incidence ascites	100%	
Volume ascites (L.)	4.0	1.2–8.0
No. of times choker was tightened before ascites appeared	1.8	1–7
Total no. of times choker was tightened	2.4	1–8

†† Intramedic polyethylene tubing made by Clay-Adams Inc., New York, N. Y.

TABLE 2. *Pressures in the Portal Vein and Abdominal Inferior Vena Cava Obtained Before Hepatic Vein Ligation, Immediately After Hepatic Vein Ligation with the Choker Loose, and at Re-operation After the Choker Had Been Tightened and Ascites Was Massive*

	No. Dogs	Portal Vein Pressure (mm. Saline)		Vena Cava Pressure (mm. Saline)	
		Mean	Range	Mean	Range
Control	37	96	54–158	52	10–101
After hepatic vein ligation (choker loose)	27	117	70–198	54	10–125
At Re-operation (choker tight and ascites massive)	17	220	150–310	99	20–168

ligatures so that they could be made to slide back and forth as one unit in the outer sheath. The choker was passed posterior to the vena cava, was fixed to the diaphragm and posterior body wall with sutures and was withdrawn from the peritoneal cavity through a stab wound in the right posterior flank (Fig. 2). The choker was then buried in the subcutaneous tissues of the posterior trunk after making certain that the loop around the superior hepatic vein was loose and was not producing any constriction. The incision was closed in a manner previously described. Pressures in the abdominal inferior vena cava and portal vein were determined with a spinal manometer by needle puncture at the beginning and end of each operation and a liver biopsy was obtained shortly after the peritoneal cavity was entered.

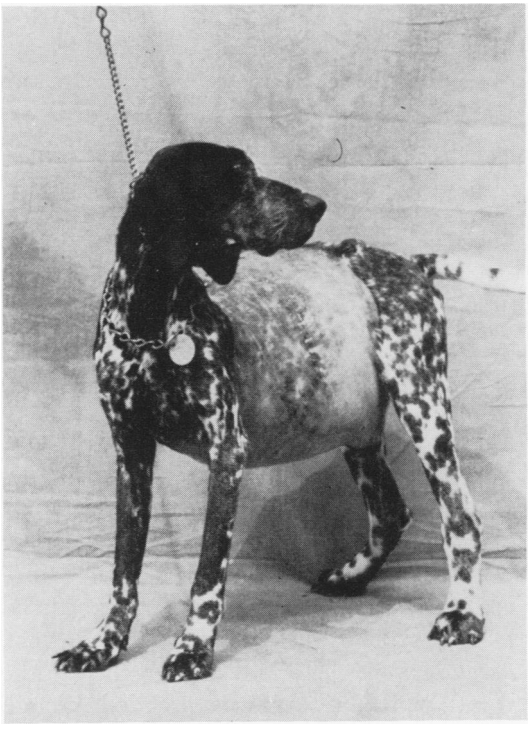

FIG. 3. Dog 910, showing massive ascites which measured 5.6 L. The photograph was taken 32 days after tightening of the superior hepatic vein choker was started. At re-operation the portal pressure was 240 mm. saline (control pressure was 82 mm.) and the vena cava pressure was 78 mm. saline.

Eighty-seven mongrel dogs which weighed from 19 to 26 Kg. were used in developing the present method of hepatic vein ligation. Thirty-seven animals survived the operation and were suitable for subsequent observations. All operations were performed with sterile technic under intravenous pentobarbital anaesthesia.

Production of Ascites. After ligation of the hepatic veins the animals were allowed to 7- to 24-day recovery period. Then at 5- to 7-day intervals until ascites became massive the buried choker was extracted under local anaesthesia, was tightened and fixed in its new position with silk ligatures and was again buried in the subcutaneous tissues. Tightening of the choker progressed in increments of 1 to 2 cm.

Following each tightening of the choker, the animal was closely observed for 1 to 2 hours for signs of acute hepatic venous outflow obstruction. On several occasions it was necessary to loosen the choker slightly because of the development of tachycardia

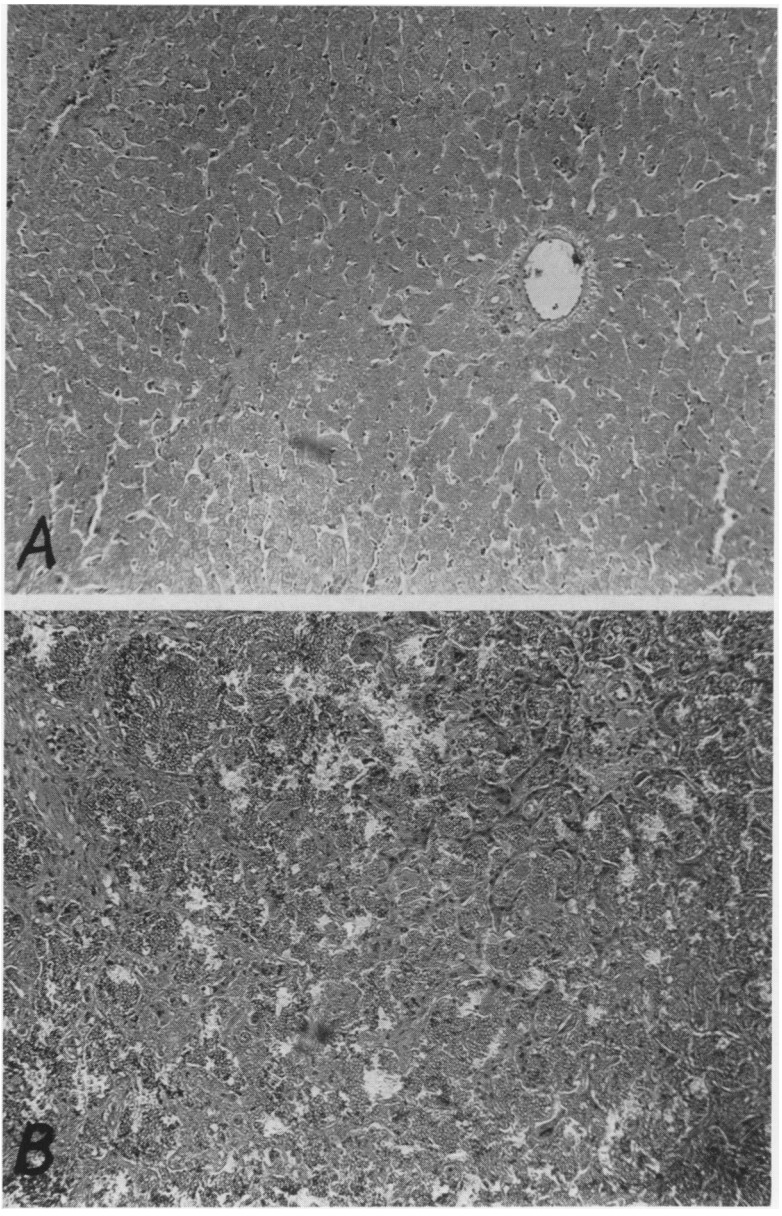

FIG. 4. Photomicrographs of liver biopsies from Dog 426 obtained (A) before hepatic vein ligation and (B) at re-operation when animal had 3.6 L. of ascites. A. Liver is normal. B. Severe congestion and necrosis of hepatic parenchyma, and liver cords are compressed and to a large extent replaced by edema fluid and blood (× 160).

and hypotension which indicated excessive outflow block. The dogs were examined daily for evidence of ascites.

Re-operation. When the ascites became massive 17 animals were re-operated upon through a right subcostal incision, the volume of ascites was measured, a liver biopsy was obtained and pressures in the portal vein and inferior vena cava were determined again. Autopsies were performed in all animals which died or were sacrificed and the volume of ascitic fluid was measured.

Results

All 37 dogs developed massive ascites following the production of hepatic venous outflow obstruction after the choker around the superior hepatic vein had been tightened (Table 1). The volume of ascitic fluid, measured at autopsy or reoperation,

ranged from 1.2 to 8.0 L. with a mean of 4.0 L. which was one-fifth to one-sixth of the body weight (Fig. 3). The choker was tightened at approximately one-week intervals, an average of 1.8 times before ascites became apparent clinically.

The results of portal and inferior vena caval pressure measurements are shown in Table 2. Immediately after ligation of all hepatic veins except the superior hepatic vein the portal pressure increased only slightly (mean increase of 21 mm.). At re-operation, following tightening of the choker and the production of massive ascites, the portal pressure was found to be elevated in all of the dogs. The mean level was 220 mm. saline which was more than twice the mean control level. The inferior vena caval pressure did not change following hepatic vein ligation. As usually occurs in the presence of massive ascites the mean inferior vena cava pressure was somewhat elevated at re-operation.

At both re-operation and autopsy the livers were found to be enlarged to two to three times normal size and were intensely congested and friable in all of the dogs. Examination of the orifice of the superior hepatic vein showed complete occlusion in 63 per cent of the animals and marked narrowing in the others. Liver biopsies showed severe hepatic congestion, hydrops and necrosis of the cells and dilated lymphatics in all animals (Fig. 4).

Summary and Conclusions

A modification of the method of producing hepatic outflow block and ascites by direct ligation of the hepatic veins was evaluated in 37 dogs. The modification consisted of inserting an externally controlled polyethylene choker around the superior hepatic vein in place of the previously used fiberglas ligature. After the animals recovered from the hepatic vein ligation the choker was gradually tightened in small increments at 5- to 7-day intervals. All 37 dogs developed massive ascites which averaged 4.0 L. In addition, the animals developed portal hypertension with portal pressures which, at re-operation in 17 dogs, averaged 220 mm. saline.

At autopsy the livers in all dogs were markedly enlarged and in two-thirds there was total hepatic outflow block with occlusion of the superior hepatic vein. Serial liver biopsies showed severe congestion, hydrops and necrosis of the hepatic parenchyma.

It is concluded that this modification of the technic of hepatic vein ligation provides a controllable and gradual method of producing hepatic venous outflow obstruction and uniformly results in massive, persistent ascites.

Acknowledgment

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