Extracorporeal Portal Decompression Using a Graphite-Benzalkonium-Heparin Shunt

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TREATMENT of bleeding esophageal varices remains a difficult problem. A significant number of patients with this condition are not suitable for emergency portosystemic venous shunt operations. Recent reports describe the usefulness of dilated umbilical veins in humans as an entry to the portal system for hepatop��ography.7, 8 White,13 Piccone,9 and Christophersen2 and co-workers used the umbilical vein for portal vein decompression. The accessibility of the umbilical and external jugular veins provides a simple means to construct a temporary extracorporeal portosystemic shunt to control bleeding varices.

The dog is a good experimental animal for study of extracorporeal portosystemic shunts since it will not tolerate portal vein ligation.3, 6 Canine survival after portal ligation is dependent upon adequate functioning of a shunt. Christophersen et al. concluded from experiments on dogs that anticoagulant agents were necessary to prevent clotting in extracorporeal shunts.2 The undesirability of anticoagulation in patients with bleeding esophageal varices is apparent. Gott and co-workers described a technic for preventing thrombosis on prosthetic materials by bonding heparin to a graphite-benzalkonium surface.4, 5 The purpose of these experiments is to evaluate the effectiveness of extracorporeal portosystemic shunts in dogs without systemic anticoagulation employing tubes coated with graphite-benzalkonium-heparin (GBH).

Materials and Methods

Healthy mongrel dogs weighing between 40 and 55 pounds underwent splenectomy 2 to 7 days prior to the experiments. Under pentobarbital anesthesia laparotomy was performed and a ligature was tied around the portal vein. Portal pressure was measured by catheterizing a large mesenteric vein. Blood pressure, pulse rate, and central venous pressure were monitored by catheters placed in the descending aorta and inferior vena cava through the femoral artery and vein.

Six dogs underwent portal ligation for 2 hours with no portal decompression and served as controls. Extracorporeal portosystemic shunts were constructed in 14 dogs. Polyvinyl cannulas 15 cm. in length with a 4 mm. internal diameter were placed in both the splenic and external jugular veins. These were joined together by a 6 mm. internal diameter polyvinyl tube 50 to 60 cm. in length using tapered nylon connectors.

The shunts in three dogs were made of tubing which had not been coated with CBH. Shunts in six other dogs were constructed and allowed to flow 2 hours through GBH coated tubing. Flows were measured by disjoining the connector and allowing blood to flow into a graduated cylinder held at the level of the right atrium. The blood was then reinfused. After two hours of portal ligation and shunting, the ligature was released and the shunt removed. Wounds were closed and the dogs were permitted to recover. In five additional dogs, GBH shunts were placed
through a subcutaneous tunnel, and the portal veins were permanently ligated. Survival time was taken as the duration of shunt function. Complete autopsies were performed in animals which died to determine the cause of death.

Results

Acute Portal Ligation. None of six control dogs survived 2 hours of portal ligation. Five died before 2 hours with a mean survival time of 81 minutes. The sixth died 4 hours after release of the ligature but did not recover from the shock induced by portal ligation. All dogs had an abrupt rise in portal pressure to a mean of 77 mm. Hg within the first 10 minutes. Blood pressure fell to below 40 mm. Hg within the first 60 minutes in all dogs (Fig. 1).

Extracorporeal Splenojugular Shunts. Three shunts constructed of tubing uncoated with GBH clotted within 35 minutes, and mean survival time was 110 minutes, not significantly longer than in control dogs.

Six dogs which underwent two hours of portal ligation with a GBH shunt survived and made excellent recoveries. Upon opening the shunt, portal pressure rapidly fell to preligation levels and remained there for the duration of the shunt. Blood pressure stabilized at a mean of 20 mm. Hg below preligation level (Fig. 2). Flows ranged from 180 to 445 cc./min. and remained relatively constant for each dog. There were variable changes in pulse rates and central venous pressures. Five dogs were well when sacrificed 7–30 days after operation. The sixth dog died of distemper 6 days after the shunt. At autopsy bowel and portal vein were normal. There was no clot formation or thrombin deposit in the GBH shunts used for 2 hours.

Long-term Splenojugular Shunts. Three dogs survived for between 4½ and 5 hours after permanent portal vein ligation and subcutaneous implantation of a GBH shunt. At autopsy, clot was found filling each shunt. Although no formed thrombus was found, the clot was mildly adherent to the ends of the splenic and jugular cannulas. In the fourth dog, the GBH surface was applied more meticulously, and the dog survived 9½ hours. At autopsy clot originated from formed thrombus at the junction of the jugular catheter and the tapered connector which was imperfect and a probable source of turbulent flow. In the fifth dog, larger splenic and jugular cannulas, measuring 5 mm. in internal diameter, were
used and eliminated the need for tapered connectors and provided more streamlined flow. This dog survived 3 days during which it was alert, walking, eating and drinking. Death was caused by thrombosis at the tips of both the splenic and jugular cannulas.

Discussion

According to previous reports, 60 to 100 minutes of portal vein ligation without a shunt in dogs invariably resulted in death.Christophersen et al. demonstrated the effectiveness of an external shunt in 6 dogs for 1 to 2 hours after portal vein ligation, but used anticoagulant drugs and an external roller pump. Mean flow was 147 cc./min. In our experiments, six dogs protected by GBH coated shunts survived temporary portal vein ligation for 2 hours. No systemic anticoagulation was employed and the portasystemic pressure gradient served as the driving force. Flows ranged from 180-445 cc./min. which are comparable to flows of 140-450 cc./min. reported in human transumbilical shunts.

With permanently implanted portajugular shunts dogs survived for 4 and 1/2 hours to 3 days after portal vein ligation. Death resulted from eventual clotting of the shunt at its junction with the venous system or at points of turbulent flow. Whiffen, Boake and Gott studied the antithrombotic properties of GBH prosthetic grafts of various diameters in the venous system. Grafts of 7 mm. diameter or more had a long-term patency rate of 83%, while long-term patency could not be achieved in grafts of 4 mm. diameter or less. Whiffen and Gott found that streamlining, exact fit, and reduction of intimal trauma by the prosthesis were important factors in thrombus prevention. Clots often originated on traumatized venous intima adjacent to the GBH prosthesis with propagation of the clot into the lumen of the prosthesis and eventual obstruction. The dog has a great propensity to form thrombus on any foreign intravascular surface or its own damaged intima. Thus the success of GBH coating in preventing clotting of 4 and 5 mm. portasystemic shunts for up to 3 days is encouraging. Since the umbilical vein can be dilated to a diameter of 7 mm. in 80% of human beings, it seems likely that the larger tubing which could be used in patients would result in portal decompression for much longer periods.

Seven prosthetic transumbilical portasystemic shunts have been constructed in patients without use of a pump or anticoagulants and have been effective in decompressing the portal system temporarily. Clotting has not been a major difficulty, but the shunts have generally been used for a short time and the patients had clotting deficiencies. White, Slapak, and MacLean reported the longest functioning shunt which lasted 5 days in a patient with severe clotting abnormalities. After 5 days, thrombus formed on the distal superior vena cava catheter, although it did not obstruct flow. Providing effective portal decompression with GBH coated shunts for more prolonged periods in patients who are not suitable for emergency portasystemic venous anastomoses appears feasible and worthwhile. In addition, the transumbilical shunt may provide an opportunity to predict the likelihood of hepatic encephalopathy after portacaval or other types of permanent shunts.

Summary

1. An extracorporeal shunt from the splenic vein to the external jugular vein successfully decompressed the portal bed and permitted survival of dogs undergoing portal vein ligation.

2. The antithrombogenic surface coating graphite-benzalkonium-heparin (GBH) prevented clotting within the shunt for 2 hours while non-coated tubing clotted.
within 30 minutes. One GBH shunt remained unclotted and functional for three days.

3. GBH coated tubing may be useful as an extracorporeal shunt in patients undergoing transumbilical portal decompression.

References