Hypothermia in Experimental Hepatic Surgery.* (20443)

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Hypothermia has been used recently(1-5) to perform intracardiac operations under direct vision without recourse to the use of extracorporeal blood pumps. The success of this technic is due to the greatly lowered oxygen requirements at reduced temperatures which allow a relatively long period of total inflow occlusion. The brain, which is the crucial organ during the cardiac operations, can apparently withstand anoxia about twice as long at a temperature of 26°C as it can at the normal body temperature. Presumably other organs as well could tolerate longer periods of anoxia during hypothermia, and may in this state, after temporary local vascular occlusion, be subjected to longer bloodless operations than could be attempted with safety at normal temperatures. If successful, this use of hypothermia might have practical value as an aid in performing extensive liver resections.

For surgery of the liver, the advantage of a bloodless field provided by prolonged complete vascular occlusion is obvious. It has been our experience, however, to find that complete hepatic vascular occlusion is not tolerated long at normal body temperatures (6,7). Hence, we have investigated the efficacy of hypothermia in allowing vascular occlusion of a satisfactory duration. At normal body temperatures the maximum period of continuous hepatic artery and portal vein occlusion tolerated by dogs without resulting in some deaths was found to be 20 minutes. After this, as the period of anoxia was lengthened, the fatality rate increased so that when the period of occlusion was extended to one hour there was only one survivor in 49 experiments. This high fatality rate occurred in spite of the fact that 46 of these dogs received antibiotics to prevent growth of the anaerobic bacteria which normally inhabit the canine liver(8-11).

Methods and results. The small, mongrel, adult dogs used in these experiments were given a combination of antibiotics for 48 hours prior to surgery. Aureomycin was given orally twice a day in 500 mg doses while penicillin was given intramuscularly twice daily in doses of 150,000 units. After fasting for 12 hours, the dogs were anesthetized with a 2.5% solution of sodium pentothal intravenously and cooling was started. Anesthesia was maintained to prevent shivering but when the temperature had fallen to 28°C no further anesthesia was needed. After the body temperature had reached 30°C the dogs were given artificial respiration by means of an electronic respirator. Body temperature was measured by means of a rectal thermometer inserted to a distance of 3 inches.

Each dog was cooled by wrapping the entire animal in rubberized blankets through which flowed a cold alcohol solution at a temperature slightly above the freezing point of water. Postoperatively, warming was accomplished with the same blankets, the circulating solution having been heated.‡

The operation was begun when the animal's temperature had dropped to 28°C or lower. Using aseptic technic, the first step was to clamp the celiac axis and the superior mesenteric artery to prevent the intestinal engorgement which would otherwise follow the subsequent venous occlusion. Then, within one minute, the hepatic artery was occluded distal to the point of origin of the gastroduodenal artery and the portal vein was occluded just before it entered the liver. The period of vascular interruption was one hour, after which the clamps were removed, the abdomen was closed, and the animal warmed as described.

Eleven dogs were submitted to the above

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‡ The cooling apparatus was manufactured by the Therm-O-Rite Products Corporation, Buffalo, N. Y.,

TABLE I. Effect of Hypothermia on Liver Anoxia.

Dog No.	Lowest body temp.	Results: Died	Results: Survived	Autopsy findings
1	22°C	×		Liver necrosis
2	25°C	×		Hemorrhage in liver cords
3	28°C		×	Normal liver when sacrificed at 21st postoperative day
4	28°C	×		" " microscopically
5	26°C		×	" " when sacrificed at 20th postop. day
6	26°C		×	" " " " " 20th " "
7	26°C		×	" " " " " 14th " "
8	25°C		×	Died at 21st postoperative day with unexplained abdominal abscess. Liver was normal
9	26°C		×	Died at 21st postoperative day of pneumonia. Liver was normal
10	26°C		×	Normal liver when sacrificed at 21st postoperative day
11	26°C		×	" " " " " 56th " "

procedure and the results are tabulated in Table I. Animals surviving the operation for a period of 2 weeks are listed as survivors since our previous experience with the control animals(7) indicated that dogs dying of liver necrosis following complete vascular occlusion usually died within the first 2 postoperative days.

Discussion. Previously we reported a fatality rate of 100% among 46 dogs submitted to occlusion of the total afferent hepatic circulation when antibiotics were administered (7). This fatality rate was reduced by the preoperative administration of the adrenocorticotropic hormone obtained from hog pituitaries so that, among 36 animals so treated, 17 survived. The factors that might have led to this increased survival rate in the treated animals have been discussed in the earlier paper.

The present experiments indicate that hypothermia, too, was effective in reducing the fatality rate which followed afferent hepatic vascular occlusion maintained for one hour. The influence of hypothermia is, as was mentioned earlier, doubtless due to its effect in reducing the metabolic activity of the liver. Our experiments do not indicate whether corticotrophin or hypothermia is more competent in reducing the toxic effects of hepatic vascular occlusion and we have not yet tested the efficacy of using them simultaneously. The experimental evidence presented suggests, however, that one, or the other, or a combination may prove to have a practical clinical value in facilitating massive resections of the liver.

Summary. When hypothermia is induced in dogs prior to the production of liver anoxia by completely occluding the afferent hepatic circulation, the mortality rate of the procedure is greatly reduced (27.2%) as compared to that previously reported in control animals (100%).

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