Short communications

Effect of temperature on the intra-hepatic vasculature

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In the isolated perfused liver of the dog, cooling produced vasoconstriction in the hepatic arterial bed and, particularly, in the vascular bed of the portal vein. Raising the temperature to 40° C dilated the portal venous bed but did not change hepatic arterial resistance. The portal venous bed is very sensitive to variations in temperature.

Hypothermia leads to restricted hepatic circulation (Brauer, Holloway, Krebs, Leong & Carrol, 1954; Fisher, Fedor, Lee, Weitzel, Selker & Rus, 1956; Halett, 1954; Petter, 1963; Wangensteen, Rahood, Luke & Healy, 1961) but its effect on the portal venous flow is not clear (Hinburger, Teramoto & Shoemaker, 1960; Wangensteen *et al.*, 1961). The purpose of our investigation was to study the local effect of variations in temperature on hepatic arterial, portal venous and total hepatic flow in the isolated perfused dog liver.

Methods.—The isolated liver of the dog was perfused with modified Tyrode solution (pH=7·35±0·15) gassed with 95% oxygen and 5% carbon dioxide (Geumei & Mahfouz, 1968; Geumei, Issa & Mahfouz, 1969). The hepatic artery and the portal vein were perfused simultaneously and the perfusate was collected from the hepatic veins by means of a cannula inserted in the inferior vena cava. The hepatic arterial perfusion pressure was kept constant throughout the study at 120 mmHg (1 mmHg≡1·333 mbar) as was that of the portal vein at 10 mmHg. Hepatic arterial and portal venous inflows (ml/min) were measured for a 30 min 'control period' at 37° C. The temperature of the perfusing fluid at the inflow cannulae was adjusted to 40°, 33°, 28°, 18° and 15° C for 20 min periods. Hepatic arterial, portal venous and total hepatic flows at each temperature were calculated as percentages of the control flow at 37° C.

Results.—These are shown in Table 1. In 10 preparations, changing the perfusate temperature from 37° to 15° C caused a steady decrease in hepatic arterial, portal venous and total hepatic flow. As constant perfusion pressures were maintained in both the hepatic artery and the portal vein an increase in flow was assumed to indicate vasodilation and a decrease vasoconstriction. Cooling caused an increase in hepatic vascular resistance, the portal venous bed being most affected. Raising the perfusate temperature to 40° C increased portal venous and the total hepatic flow but did not change the hepatic arterial flow.

Discussion.—These experiments suggest that the rise in total hepatic vascular resistance in response to hypothermia is largely due to increased portal venous resistance. Different methods and techniques have also shown that hypothermia leads to restricted hepatic circulation. Some investigators reported that the decrease in hepatic flow is proportional to the reduction in cardiac output (Fisher *et al.*, 1956; Halett, 1954), while others found that it is greater than the diminution of cardiac output (Brauer *et al.*, 1954; Teramoto & Shoemaker, 1962). Grimes & Lewis (1963) found that cooling causes increased mesenteric resistance most of which is due to arterial constriction.

However, previous studies of hepatic circulation in hypothermia have used

TABLE 1. *Effects of variations in temperature on hepatic flow*

	40° C	37° C (Control)	33° C	28° C	18° C	15° C
Hepatic arterial flow	100·00	100%	96·65 ±1·30	92·8 ±1·55	87·29 ±1·78	82·16 ±1·24
Portal venous flow	108·93 ±0·77	„	93·87 ±0·60	87·99 ±0·74	83·03 ±1·07	75·82 ±1·30
Total hepatic flow	106·22 ±0·48	„	94·69 ±0·58	89·30 ±0·74	84·12 ±1·19	77·65 ±1·17

The values were the means of ten observations (% of control flow at 37° C)±standard error.

methods which measure total hepatic flow only. Our results indicate that the increased vascular resistance in the isolated perfused liver which occurs after cooling was due chiefly to constriction of the portal vein. The response is a local one and no reflex is involved. As we use Tyrode solution, the response is not due to temperature dependent variations in the physical or chemical properties of the blood, as reported by Eisenman, Knipe, Normell & Spencer (1963). Our perfusion fluid was not recirculated, was of constant composition and did not contain blood cells, hormonal agents or vasoactive metabolites. Hence the constriction of the hepatic artery and portal vein induced by cooling was probably due to a direct effect.

The similarity of behaviour of the systemic and the portal vein to changes in temperature is striking. The constriction of superfacial veins which is induced by hypothermia was demonstrated by Donegan (1921) and was confirmed recently both in the intact animal (Webb-Peploe & Shepherd, 1968; Webb-Peploe, 1969) and in isolated canine cutaneous and mesenteric vein preparations (Vanhoutte & Shepherd, 1969, 1970). Constriction of pulmonary veins under cooling was reported by DePasquale, Burch & Hyman (1965).

Our study shows that the portal venous bed is particularly sensitive to variations in temperature.

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