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THERMAL STIMULATION OF INTRA-ABDOMINAL VEINS IN CONSCIOUS RABBITS

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SUMMARY

1. Infusions of hot and cold Hartmann's solution were given into the hepatic portal vein and inferior vena cava of conscious rabbits. Similar infusions were given into an ear vein as controls. The time integral of the displacement of brain temperature was measured.

2. There was no evidence for the presence of warm sensors in the inferior vena cava, portal vein, liver or hepatic vein, and no evidence for a concentration of cold sensors in the inferior vena cava.

3. There may be cold-sensitive elements in the portal vein or the tissue perfused by blood passing through it.

INTRODUCTION

There is evidence to suggest that there may be central thermosensors within the abdomen, though their location has never been exactly defined (Rawson & Quick, 1972; Riedel, Siaplauras & Simon, 1973). Rawson & Quick (1972) showed that unilateral splanchnic section abolished the effects of ipsilateral heating of the posterior abdominal wall, and on the basis of this evidence suggested that it was unlikely these receptors lay within the liver, but there is no direct evidence for this. It has also been suggested, again on indirect evidence (Bligh, 1961; Blatteis, 1960) that there might be central thermosensors in the inferior vena cava.

We have examined these possibilities by infusing warm and cold fluid into the portal veins and inferior venae cavae of rabbits, and observing the response of brain temperature. The rationale for this approach has been described previously (Cranston, Hellon & Townsend, 1977); briefly, an infusion of warm or cold fluid into a vessel supplying an area containing a high concentration of thermosensors would be expected to produce a smaller deviation of brain temperature than an identical infusion into a vessel devoid of such sensors.

METHODS

Eighteen rabbits of either sex weighing 2–3·5 kg were prepared at a preliminary operation under general anaesthetic (alphaxalone and alphadolone: Althesin, Glaxo). With sterile precautions, a laparotomy was performed and polyethylene catheters (o.d. 1·2 mm) inserted into the inferior vena cava, approximately 20 mm caudal to the junction of the left renal vein, and the portal vein, about 30 mm from the porta hepatis. The catheters were sealed into the vessels with cyanoacrylate cement (Permabond), anchored with sutures and led to the abdominal skin

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where they were connected to a subcutaneous metal plate (Cranston, Hellon, Riley & Townsend, 1977). The whole catheter was then filled with concentrated heparin solution (Boots 5000 u./ml.) and heat sealed. The intra-abdominal length of the catheter was the same for the portal vein and inferior vena cava (approximately 90 mm). At the same operation a plate was screwed to the skull for later introduction of a thermistor to measure brain temperature (Monnier & Gangloff, 1961).

At least a week later, the animal was placed in conventional stocks, in a room whose temperature lay between 19 and 23 °C. Brain temperature was measured with a thermistor, and recorded at 18 sec intervals on a Leeds–Northrup potentiometer (Speedomax W). Infusions of a standard volume (45 ml.) of Hartmann's solution (Compound Sodium Lactate, B.P.) were administered at a fixed rate of 22·9 ml./min using a Harvard pump. As a control, similar infusions were given into the marginal vein of the ear. Cold infusions were given at room temperature; for hot infusions, the fluid was passed through a copper coil immersed in a stirred water-bath, maintained at such a temperature that the fluid entered the rabbit at a temperature of about 46 °C.

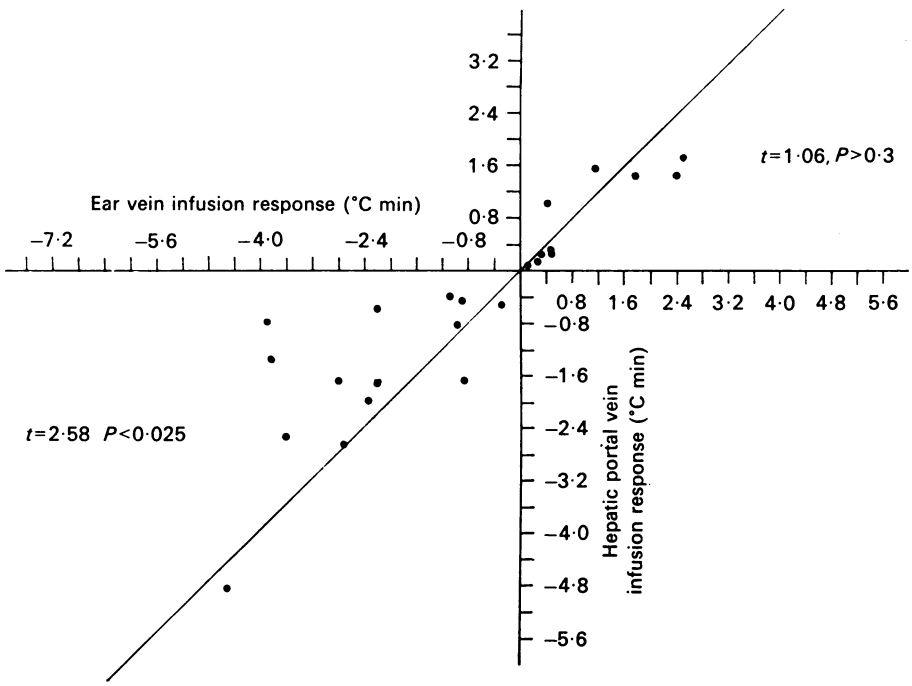

Fig. 1. Comparison of the displacements of brain temperature following cold (lower left quadrant) and hot (upper right quadrant) infusions into an ear vein or the hepatic portal vein. The line is that of identity.

The order of infusion routes was randomized and most rabbits received six infusions, one hot and one cold into each of the three catheters. Each hot or cold infusion caused a rise or fall of brain temperature which returned towards its previous level in 5–10 min. The area between the curve described by brain temperature and an interpolated straight base line was measured by planimetry and expressed in °C.min. This area has been termed the response.

The degree of thermal exchange across the walls of the abdominal catheters was measured in one anaesthetized animal. Thermocouples were passed along the catheters entering the portal vein and inferior vena cava so that their junctions lay 2–3 mm within the catheter tips. A similar thermocouple measured the temperature of infused fluid at the point where it entered the ear vein. Three or four cold infusions, at room temperature, were given through each catheter. The temperature of fluid entering the portal vein and inferior vena cava averaged 1·94 and 1·56 °C respectively, above the temperature of fluid entering the ear vein.

RESULTS

We have compared the responses following hot and cold infusions into the hepatic portal vein or the inferior vena cava with the responses following infusions into the ear vein. The comparisons are shown in Figs. 1 and 2. The significance of the differences between the responses following infusion into the ear vein and one of the abdominal veins was assessed using a paired t test.

Following hot infusions, there was no significant difference between the responses to ear vein infusions and those to infusions into the portal vein ($t = 1{\cdot}06$, $P > 0{\cdot}3$) and inferior vena cava ($t = 0{\cdot}4$, $P > 0{\cdot}6$).

After cold infusions, the ear vein and inferior vena cava responses were again not significantly different ($t = 1{\cdot}56$, $P > 0{\cdot}1$). In contrast, as can be seen in Fig. 1, the responses to cold infusions into the portal vein were slightly but significantly smaller than those to ear vein infusions ($t = 2{\cdot}58$, $P < 0{\cdot}025$).

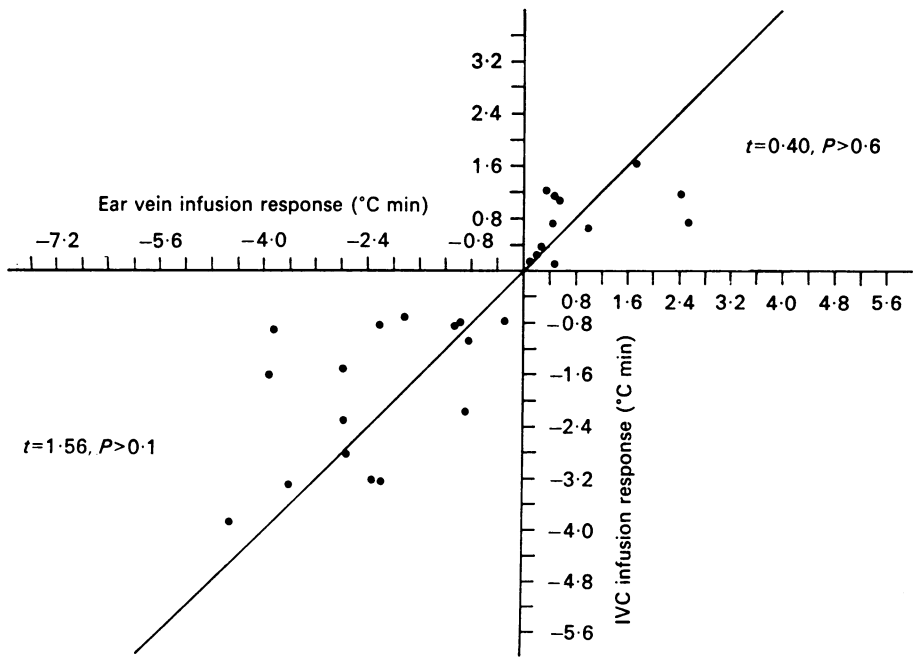

Fig. 2. Comparison of the displacements of brain temperature following cold (lower left quadrant) and hot (upper right quadrant) infusions into an ear vein and the inferior vena cava (IVC). The line is that of identity.

DISCUSSION

Our evidence does not suggest that warm or cold sensors are present to any important extent in the inferior vena cava above the level of the infusion site, because the responses to the same thermal loads given into the ear vein and inferior vena cava were not distinguishable.

The responses to hot infusions given into the ear vein and the portal vein were likewise not different. This implies that there is no major concentration of warm

sensors between the point of infusion into the portal vein and the junction of the hepatic vein and inferior vena cava.

Since the responses to cold infusions given by the portal route were smaller than those to the same infusion into the ear vein, it is possible that there may be a functionally important concentration of cold sensors in the portal vein, liver or hepatic vein, but the effective reduction in thermal load entering the portal vein, as indicated in the methods section, makes this possibility less likely.

Previous work has indicated that both sheep (Rawson & Quick, 1972) and rabbits (Riedel *et al.* 1973) possess warm sensors somewhere on the posterior abdominal wall. The evidence for cold sensors in the same area in rabbits is less convincing. Riedel *et al.* (1973) found negligible reductions in respiratory rate and no change in ear skin temperature when an abdominal thermode was perfused with cold water.

Rawson & Quick (1972) used electrical heaters to demonstrate the presence of warm sensors in the abdomen. Their rate of heating was of the order of 0·3–0·5 W/kg for periods of 30–40 min giving total loads ranging from 9 to 20 W.min/kg. In our experiments with warm infusions the rate of heating was 4–7 W/kg delivered over 2 min or 8–14 W.min/kg, a very similar range. Thus our failure to find evidence for warm sensors is not due to a difference in the size of the thermal loads.

Wherever the intra-abdominal warm sensors may be, our evidence shows that they are not in the vena cava, portal vein, liver or hepatic vein.

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