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Cardiac Temperature Gradients During Profound Hypothermia with Extracorporeal Perfusion.* (26307)

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Whether or not cardiac temperature gradients during induction of hypothermia and rewarming are related to onset of ventricular fibrillation remains equivocal. That such differences in temperature do occur has been reported by Brooks(1), but no experimental data have been presented. He further added that " . . . such studies have not been carried far enough to justify statements other than that marked gradients are present when the heart is susceptible to fibrillation or is difficult to defibrillate." Prior to this Hegnauer (2) speculated that such gradients would be expected and might be responsible for ectopic activity in the ventricles. Because of the paucity of information relevant to cardiac temperature variations and fibrillation when either immersion or direct blood cooling was used to produce hypothermia, such a study was undertaken using the latter method in conjunction with extracorporeal perfusion.

Materials and methods. Fourteen mongrel dogs of both sexes, weighing 12 to 20 kg, were anesthetized with pentobarbital sodium, 25 mg/kg, attached to a Medtronic automatic respirator and connected to an extracorporeal system (consisting of a T. M.-2 Sigmamotor perfusion pump, a 13″ convoluted disc Kay-Cross oxygenator, and a gas type heat exchanger)(3) which permitted control of cooling and rewarming. The unit was primed with heparinized whole blood. An inflow catheter was inserted *via* a femoral artery into the aorta at the level of the renal arteries, and outflow catheters were placed in the vena cavae through femoral and jugular veins. Prior to cooling a thoracotomy was performed and 5 or 7 copper-constantan thermocouples† were implanted in various sites of the heart. Following closure of the thorax a similar thermocouple was passed orally into the mid-esophagus. The precise position of all thermocouples was confirmed by sacrifice of animals at conclusion of each experiment. Temperatures were automatically registered every 30 seconds on a Leeds-Northrup Speedomax Type G recorder. Variations of temperature as slight as 0.1°C could be detected. Cardiac activity was continuously monitored by a Sanborn Visoscope and recorded intermittently on a Sanborn Polyviso. The perfusion rate during cooling and rewarming was maintained at 50 cc/kg/min. Cooling was continued until the esophageal temperature registered 10°C, at which time rewarming was instituted. Perfusion was discontinued when esophageal temperature was between 25 and 30°C.

Results. Cardiac temperature differentials were noted in every animal studied. Four examples, each from a separate animal, representing the usual variations observed are shown in Fig. 1. Although temperatures were simultaneously obtained from sites other than those illustrated, for clarity of presentation they were omitted when they were similar or close to the ones that were used. While temperatures recorded from vari-

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† Type NN-30-DT-Cu-Constantan-30 gauge BNS, Nylon Insulation—Thermo Electric Co., Inc., Saddle Brook, N. J.

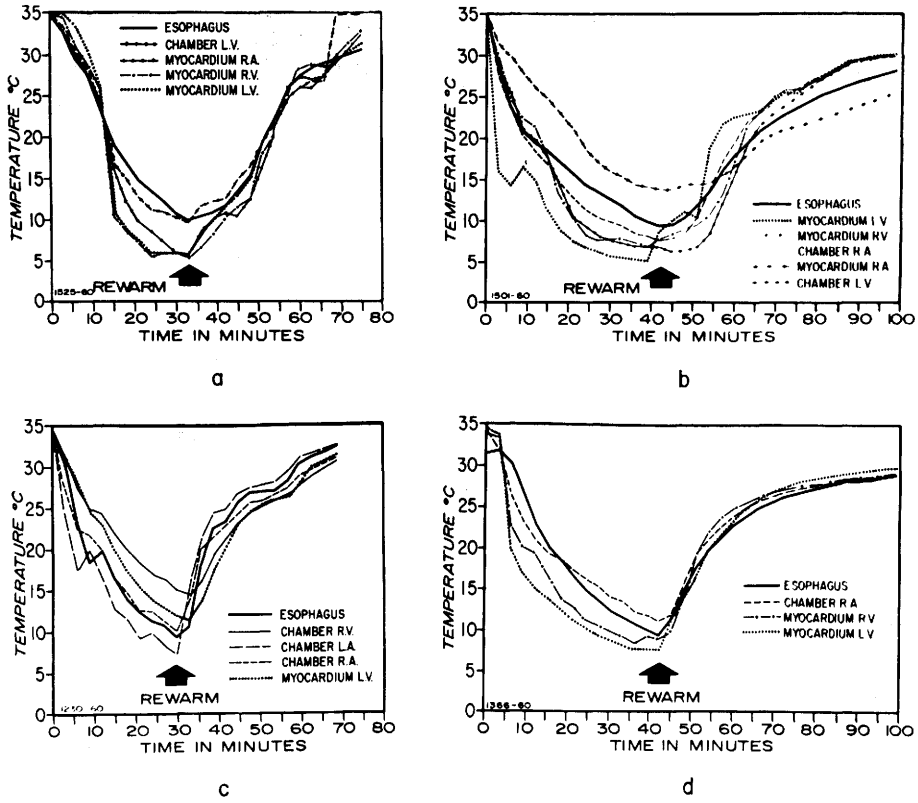


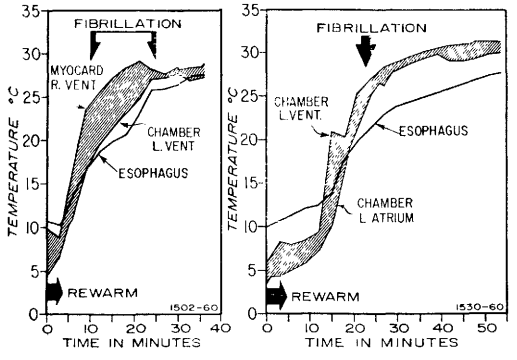
FIG. 1. Cardiac temperature gradients in 4 representative animals subjected to profound hypothermia and rewarming with extracorporeal perfusion.

ous parts of the normothermic heart showed little variation, with onset of cooling differences were at once apparent. Magnitude of the deviations differed from animal to animal. For example, 6 minutes after onset of perfusion, when mean esophageal temperature of all animals was 27°C, dog #1525 (Fig. 1-a) demonstrated a 2°C difference between right and left ventricular myocardium, whereas, in dog #1501 (Fig. 1-b) the difference was 11°C. After 12 to 15 minutes of cooling, when esophageal temperature of the animals was between 17 and 22°C, a critical temperature in so far as onset of fibrillation is concerned, temperature differences were more pronounced. A correlation was noted between decrease in heart rate and increased temperature gradient. As cooling continued to 10°C (esophageal) remarkable temperature variations were noted. In dog #1501 (Fig. 1-b), just prior to rewarming the right auricular myocardium was 14°C, while the left ventricular myocardium was 5.2°C.

With onset of rewarming, most animals promptly demonstrated a decrease in temperature variation, but in some, as rewarming proceeded, increased gradiations again became more apparent (Fig. 1-b). Probes from locations which manifested the greatest and most rapid fall in temperature during cooling revealed the reverse upon rewarming.

As cooling progressed, esophageal temperatures in most animals less closely approximated heart temperatures. The examples in Fig. 1 demonstrate that at 10°C the latter was ± 5°C of the esophageal readings. During rewarming the same discrepancy was observed.

Of the 14 animals in this study, none fibrillated during the cooling phase; 2 (Fig. 2-A and B) did during rewarming. No characteristic difference in temperature pattern, however, could be ascertained in the latter



A B

FIG. 2. Cardiac temperature gradients in 2 animals subjected to profound hypothermia and rewarming with fibrillation during rewarming.

dogs from that observed in those which did not fibrillate.

Discussion and conclusion. It is apparent from these studies that induction of hypothermia by extracorporeal perfusion and direct blood cooling results in marked gradients of cardiac temperature. In view of the fact that not a single animal fibrillated during cooling, it would seem that either (1) such gradients *per se* are not a factor in invoking fibrillation, or (2) the gradients must be of greater magnitude than those observed. During rewarming, when fibrillation did occur in 2 instances, temperature patterns were no different from those of animals without arrythmias.

An obvious explanation for the usual temperature gradients encountered and the variation between animals rests on the premise that there is a difference in blood flow through the various portions of the heart. This in turn may be related to catheter position, pump flow rates and other as yet unknown hemodynamic changes. For example, the precise location of the outflow catheters could well determine volume of blood available for circulation through the pulmonary vascular bed. As a consequence of such flow differences, it is also probable that oxygen gradients are likewise present. In view of the possibility that such a situation disposes to fibrillation(4), further study of this facet is contemplated.

Summary. During the production and reversion of profound hypothermia with extracorporeal perfusion temperatures were recorded from various sites throughout the heart. In all animals studied thermal gradients were observed. In some instances during cooling temperature variations as marked as 10°C were recorded. During rewarming similar differences were noted. From these studies it is concluded that thermal gradients alone are not responsible for hypothermic ventricular fibrillation.

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Fibrinolytic Activity in Fluid from Gingival Crevice.* (26308)

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Recent investigations have demonstrated the presence of fibrinolytic systems in various human body fluids(1,2,3). These systems resemble the fibrinolytic system in the blood but differ in that normally no or only very small amounts of plasminogen and inhibitory agents are present(4,5,6,7). Albrechtsen and Thaysen(8) found the fibrinolytic sys-

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