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Changes in the Electrocardiogram Associated with Intraoperative Epicardial Hypothermia

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Intraoperative electrocardiographic monitoring has long been utilized for the diagnosis and treatment of cardiac arrhythmias. Recently, multiple-lead electrocardiographic monitoring has been employed in order to detect evidence of myocardial ischemia in patients undergoing coronary-artery surgery. ST-segment depression and T-wave inversion may be early indicators of acute intraoperative myocardial ischemia.[1] This report documents a case of intraoperative T-wave inversion that might have been incorrectly diagnosed as myocardial ischemia.

REPORT OF A CASE

A 53-year-old man who had a normal preoperative electrocardiogram required anesthesia for coronary-artery surgery to relieve intractable angina. Preoperative hemoglobin, electrolytes, BUN, and glucose were within normal limits. Anesthesia was induced with Innovar, 5 ml, and maintained with fentanyl and 50 per cent nitrous oxide in oxygen. A median sternotomy was performed. The esophageal temperature decreased from 35 to 33.6 C during the pre-bypass period.

Prior to the start of cardiopulmonary bypass, epicardial lavage with bacitracin solution, 100 ml, produced sudden T-wave inversion in standard lead II (fig. 1). Within 3 minutes, the T-waves reverted to the upright position. Subsequent lavage with physiologic saline solution produced identical transient ECG changes. The temperatures of these irrigating solutions ranged from 21 to 22 C. When the heart was irrigated with saline solution at 32 C, no electrocardiographic change was observed. Mean arterial blood pressure did not change during epicardial lavage. Similar T-wave changes were observed in eight additional patients when 21–22 C bacitracin solutions were used for irrigation of the heart.

DISCUSSION

Normal repolarization of the ventricle proceeds from the epicardium toward the endocardial surface, thereby producing an upright T-wave. Epicardial cooling delays epicardial repolarization, thereby reversing the direction of the repolarization process. This change in the direction of the repolarization vector is reflected as T-wave inversion on the electrocardiogram.[2]

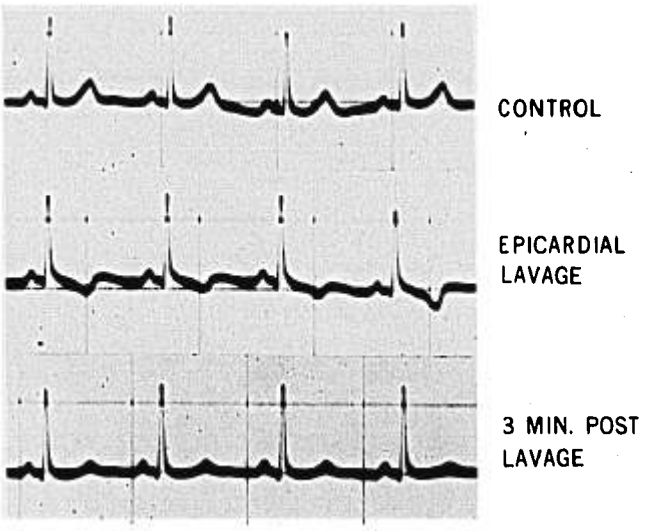

FIG. 1. ECG changes associated with epicardial cooling.

The T-wave changes we observed are similar to those found in 1923 by Wilson and Finch in awake, supine subjects.[3] These investigators discovered that drinking 600 ml of iced water produced T-wave inversion in standard lead III, a reduction in the height of the T-wave in lead II, and no change in lead I of the electrocardiogram. It was postulated that these electrocardiographic changes were due to cooling of the diaphragmatic surface of the heart by its close proximity with the distended fundus of the stomach. More widely distributed epicardial cooling, such as that produced by epicardial lavage, might be expected to produce T-wave inversion in all standard limb leads.

Intraoperative T-wave inversion may result from a number of factors, including myocardial ischemia, elevated intramyocardial pressure, hyperventilation, bundle-branch block, digitalis, acid–base and electrolyte disturbances, and hypotension.[2,4] We conclude that epicardial lavage with room-temperature solutions may also produce T-wave inversion, and suggest that epicardial cooling be included in the differential diagnosis of intraoperative T-wave changes.

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Neonatal Temperature and Surgery

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There are still many difficulties in the maintenance of normothermia during operations on the newborn.[1,2] Modern newborn intensive care succeeds in keeping alive very ill newborns who come to surgery for increasingly complex procedures requiring longer surgical times. Measures to counteract loss of body heat in the operating room increase in importance, and this report examines operating room temperature control as a means of achieving thermic stability.

METHODS

For the past two years in this institution, ambient operating room temperature has been increased for operations on the newborn (as much as 28 days old) and used as the primary method of temperature control. During this period the basic anesthetic technique has not changed: premedication is with atropine, 0.1 mg, and then the infant is transported to the operating room in an incubator. The trachea is intubated with the newborn awake, and a nondepolarizing muscle relaxant given iv into a small vein on the volar aspect of the wrist. Anesthesia is maintained with oxygen–nitrous oxide and ventilation controlled with a T-piece circuit. An iv route and appropriate monitors, including a tympanic temperature probe, are secured before positioning and preparation of the operative site. Draping includes the use of Vi-drape®, and a warming mattress is placed under the baby. Overhead heating devices are not used, anesthetic gases are not heated, and iv solutions (except blood) are not warmed.

RESULTS

All procedures were either abdominal or thoracic. The cases are summarized in table 1. The mean operative time was 125 minutes. Prematures consisted of 70 per cent of the cases.

TABLE 1. Summary of Cases

Number of babies:	33
Number premature:	23 (less than 2.5 kg)
Ages:	newborn to 28 days (mean 9 days)
Weights:	mean 1.9 kg (range 780 g–4.0 kg)
Operative times:	125 min (ranges 35–250 min)

In figure 1 mean change in body temperature during the procedure is plotted against ambient operating room temperature. Only five specific ambient temperatures were employed, and the mean changes in body temperature at each ambient temperature are shown separately for mature and premature newborns. In almost all the babies (81 per cent) temperatures increased during the surgical procedures. In most instances this was an attempt to regain normothermia, as they cooled down to an average of 1 C below normal prior to operation. Only 12 per cent had normal (37 C) body temperatures initially.

A more meaningful presentation of the results is shown in table 2. The percentage of newborns who at the end of operation had either normal body temperatures or rising subnormal temperatures (we presumed that normothermia would have been achieved) is given for each operating room temperature. The range of ambient temperatures needed for achievement of thermal stability was found. In 36 per cent of these neonates, ambient temperature control was the only method of heat control employed.

DISCUSSION

The newborn is not poikilothermic[3]; rather, temperature is maintained by the balance between heat production and heat loss. Metabolism is usually equated with body weight or surface area. Oxygen consumption, hydrogen ion production, and water turnover, all indices of heat production, are two to four times those in the adult.[4] Heat loss by conduction, convection, and radiation is greater in

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