THERAPEUTIC APPLICATION OF ULTRASOUND IN MYOCARDIAL INFARCTION: A CHRONIC SIX-WEEK STUDY IN DOGS

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Previous studies have demonstrated that appropriate administration of ultrasound has some beneficial effects on the wound healing processes. To evaluate the potential benefit of ultrasonic therapy in myocardial infarction, 40 mongrel dogs have been studied over a period of 6 weeks following ligation of the left anterior descending (LAD) coronary artery. An animal model was developed which provided an acoustical window to assure transmission of the sound waves to the anterior-lateral aspects of the left ventricle. To do this, a left thoracotomy was performed at the fifth intercostal space. A portion of the fifth rib was removed and the pericardium was incised. The incised edges of the pericardium were sutured to the thoracic wall around the chest incision to retain the cardiac lobe of the left lung. The LAD was ligated distal to the 1st or 2nd diagonal branch and the chest was closed. After the pneumothorax was evacuated the animal was returned to the animal facilities and the 6-week therapy regime was commenced. The coronary ligation was performed without prior knowledge of animal's assignment to treated or control group.

Continuous wave ultrasound (870 kHz, 1.5 watts/cm^2 average intensity) was administered to 24 dogs for 10 minutes, three times a day for 6 weeks. Sixteen control animals underwent the same surgical procedures and handling as the treated animals except that the ultrasonic transducer was not energized during their placebo massages. The transducer was coupled to the shaved chest wall with an heavy grade mineral oil and the heart was irradiated by slowly moving the transducer over an area approximately 8 cm by 8 cm. The stability of the ultrasonic therapy system was verified by a weekly calibration of the total power output on a radiation pressure balance.

Electrocardiograms were recorded before coronary artery ligation and at specified intervals throughout the study. On 13 animals rhythm monitoring was performed for extended periods via a telemetry unit and a programmed Trendscriber recorder. Serum lactic dehydrogenase isoenzymes were also obtained to verify infarctions. At the end of the study, the animals were anesthetized and the heart was excised. The aorta was cannulated and the coronary vascular bed was flushed with 2 liters of Ringer's solution under a 120 mmHg perfusion pressure. The heart was then perfused with an enzyme specific stain (NAD-NBT) which left the infarction or lactic dehydrogenase depleted area unstained while the normal myocardium stained a dark blue. The heart was then fixed with a perfusion of 2 liters of buffered 10% formalin. Transverse sections were cut 5 mm thick from apex to base. These sections were photographed and the infarcted areas were mapped by gross inspections. Histological studies were performed using Masson's tetrachrome to verify the infarcted areas on each transverse section. A blind histological evaluation was made using the amount and distribution of collagen, vascularity, and perivascular sparing as specific criteria. Each transverse section was then digitized and the area and volume data were calculated on an PDP-11/45 digital computer using a modified Simpson's Rule.

General findings include: (1) less dense collagen scarring in the treated animals; (2) 29% of the treated hearts showed no signs of infarction at termination, whereas the control group had 19% with no infarcts; (3) 42% of the infarctions in the treated group were subendocardial, whereas the control group had 31%, (4) 29% of the infarctions in the treated group were transmural, whereas the control group had 50%; (5) the infarcted areas as identified by gross and histological examinations were smaller in the treated animals; and (6) 30% of the treated animals that were rhythm monitored demonstrated a decrease in the rate of premature ventricular contractions (PVC), while one (10%) showed an increased PVC rate.

Our conclusion is that the ultrasound does have some beneficial effects. The dosages and administration format of the ultrasonic energy need to be optimized. The mechanical effects which resulted in decreased scarring during the long-term healing processes and better perfusion during the acute processes require further evaluation based on functional criteria.

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