TELEMENTRY OF HEART RATES IN LARGE RAPTORS: A METHOD OF TRANSMITTER AND ELECTRODE PLACEMENT

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ABSTRACT - Heart rates of the Red-tailed Hawk (*Buteo jamaicensis*) and Barred Owl (*Strix varia*) were monitored telemetrically. The most acceptable data were received from devices whose electrodes were anchored within the thoracoabdominal space near the apex of the heart (primary lead) and dorsum (reference lead). Easily assembled plastic backpacks and leather harnesses were designed to be comfortable to birds and also to be resistant to damage from beaks and talons.

Previously developed methods for monitoring heart rate telemetrically (Sawby et al. 1974; Busch et al. 1978; Kanwisher et al. 1978) proved unsuccessful for large raptors for several reasons. First, unsuitable arrangement of electrode leads gave unreliable results (Sawby et al. 1974) and were too difficult and time-consuming to place to be of practical value (Busch et al. 1978). Secondly, an easy, reliable method of attaching the transmitting devices to the dorsum of each bird has been lacking. In addition, Kanwisher, et al. (1978) described a method which was vague on electrode placement and included an unprotected backpack. Our objectives were, therefore, to develop a more satisfactory placement of electrodes and a safe, economical backpack and harness for transmitter attachment.

MATERIALS AND METHODS

Electronics. — Two electrodes, 1 acting as primary lead and the other as reference lead, were surgically implanted. The primary lead consisted of a 34 cm strand of Teflon-E insulated 7 x 40 cm silver coated copper wire (Beldon Electronics, Geneva, IL 60134) terminating at 1 end with a 1 mm round pin (Vector Electronic Co., Inc., Sylmar, CA 91342) and a No-Knot Eyelet fish hook (Wilson-Allen Corp., Windsor, MO) at the other end (Sawby et al. 1974), constituting a barbed-needle electrode (Fig. 1). The reference lead was constructed with the same material except that the No-Knot Eyelet was replaced with a 0.5 cm loop of uninsulated wire, constituting a circle electrode (Fig. 1). These electrodes detected action potential of high amplitude S-waves of the electrocardiogram of the raptor and the attached transmitter module converted information into short RF pulses which were transmitted in the range of 148-149 MHz (J. Stuart Enterprises, Grass Valley, CA 95945). The transmitter had a mass of 20 g and measured 2.0 x 1.5 x 8.5 cm (Fig. 1).

Surgical Procedure. — Subjects wre anesthetized with an intramuscular injection of Ketamine Hydrochloride (Fowler 1978) and Acepromazine Maleate into the muscles of the leg. The Acepromazine Maleate reduces the muscle spasms resulting from the use of Ketamine Hydrochloride as the principal anesthetic (Fowler 1978). Satisfactory dosages were 15-25 mg/kg of a 10:1 Ketamine/Acepromazine solution.

A 1 cm incision was made along the abdominal midline 0.5 cm posterior to the sternum, roughly following the method proposed by Sawby et al. (1974). Using a curved hemostat, the barbed-needle electrode of the primary lead was inserted cranially through the incision into the abdominal cavity (Fig. 2) and advanced along the peritoneal surface of the keel, to a position as close as possible to the apex of the heart, then imbedded into the sternum. The remainder of the lead was passed laterally from the incision subcutaneously to a point just posterior to the left wing. It was usually necessary to open this track with a blunt probe before pushing the lead through. A 0.5 cm incision was made to allow the lead to exit. This lead was similarly tunneled from the point of lateral incision to a point on the median of the dorsum. Another incision was made to allow exit of the lead and removal of the slack All incisions were closed with 3-0 gut suture.

The circle electrode on the reference lead was anchored subcutaneously with 3-0 gut suture to muscle tissue at the point of the dorsal incision (Fig. 2). This incision was then closed with 3-0 gut suture, leaving both leads protruding out of the skin. The procedure usually lasted about 20 min.

Salvaged raptor carcasses were dissected prior to this study to practice locating heart and surrounding structures before beginning on a live bird. Also, domestic fowl (*Gallus* sp.) were implanted with electrodes to perfect surgical technique and electrode placements.

Backpack and Harness. — A backpack was constructed of 10 cm of 2.6 cm (i.d.) clear plastic tubing (Kirkill, Inc., Downy, CA 90241) and end-caps consisting of plastic 35 mm film canisters. A leather harness was made by riveting 2 strips of leather (each 1.5 cm wide) to the dorsal wall of the backpack (Fig. 3). The contact pins of both leads were passed through a hole in the ventral wall of the plastic tubing and connected to the transmitter inside of the tubing. Leather straps were passed around the wings of the bird to the ventrum and riveted together (Fig. 2).

Data Collection. — Signals were received by a portable unit consisting of 3 components: a hand-held antenna, a radio receiver, and a strip-chart recorder (J. Stuart Enterprises, Grass Valley, CA 95945). The receiver was a Telonics Model TR-2 direct-frequency reading, synthesized triple heterodyne, AC/DC receiver which measured 11.5 x 5.1 x 18.0 cm. The recorder was a Gulton Model 288 DC recorder which utilized pressure sensitive strip-chart paper to record an instantaneous average of heart rate in beats/min at 2-sec intervals. This unit measured 15.3 x 22.9 x 19.1. The normal DC mode of the recorder was converted to AC by the use of a current transformer. A programmable household timer (Radio Shack/Tandy, Ft. Worth, TX 76113) was used to turn on the recorder at previously determined intervals. The graphs produced resembled that in Fig. 4.

Two Red-tailed Hawks, 1 Great Horned Owl (*Bubo virginianus*) and 1 Barred Owl were affixed with transmitters. All were victims of crippling injuries to 1 wing and thus incapable of flight and had been received from the rehabilitation unit of the Raptor Rehabilitation and Propagation Project, Inc. Each bird was housed in an outdoor enclosure (2.5 x 5.0 x 2.5 m) after implantation and recovery.

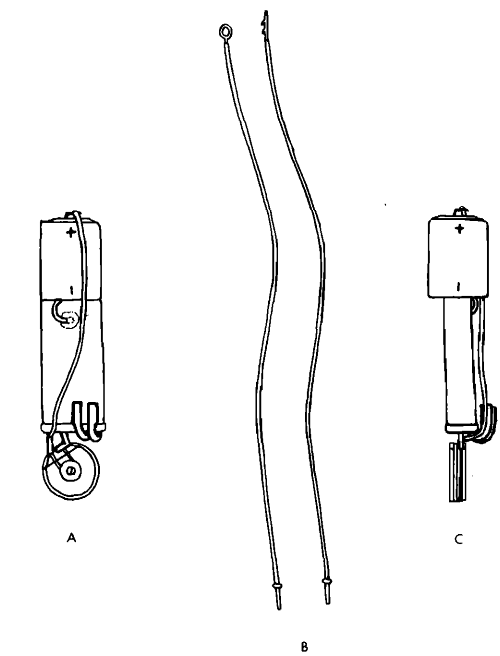

Figure 1. A and C: Bottom and side views of transmitting device; B: Primary lead and reference lead.

RESULTS AND DISCUSSION

Signals from the heart rate transmitter were received up to a distance of 1 km. Lithium batteries in each of the 3 units used were in continuous operation for over 1 yr, with no apparent reduction in performance. The backpacks and leads, when properly placed, remained functional for at least 1 mo. The backpacks and leads were checked daily for damage. We believe that the method of recording was less complex to operate and more easily monitored than day-to-day methods previously reported (Sawby et al. 1974, Busch et al. 1978, Kanwisher et al. 1978).

Difficulty in implanting the barbed-needle electrode of the primary lead was encountered with older birds whose skeletons had undergone more ossification. Implanting the electrode in the lateral edge of the sternum may prove adequate if normal implantation is not possible.

Placement of the leads proved critical. The primary lead did not respond satisfactorily if placed outside the abdominal cavity or if placed loosely inside the abdominal cavity. The barbed-needle electrode on the primary lead provided a secure long-lasting anchor inside the body cavity in proximity to the apex of the heart. Care was taken during the implantation to prevent accidental injury to internal structures, especially pericardium.

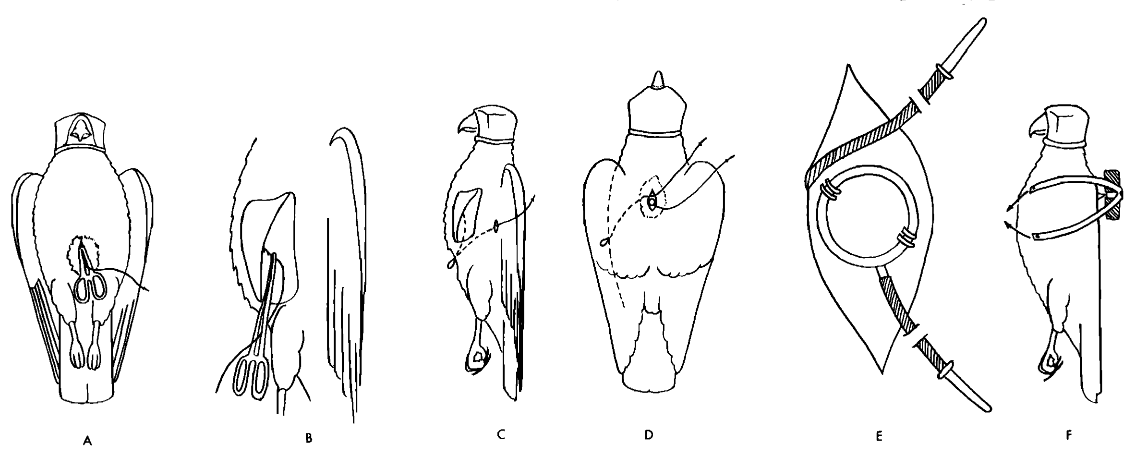

Figure 2. A: Ventral insertion of internal (primary) lead near end of keel; B: Side view of barbed-needle electrode of internal lead being pushed into dorsal side of keel through ventral incision; C: Subdermal insertion of internal lead toward dorsal exit point; D: Dorsal view showing exit of internal lead and surgical implantation of external (reference) lead; E: Enlarged view of subdermal attachment of reference lead and exit of primary lead; F: Attachment of harness containing transmitter.

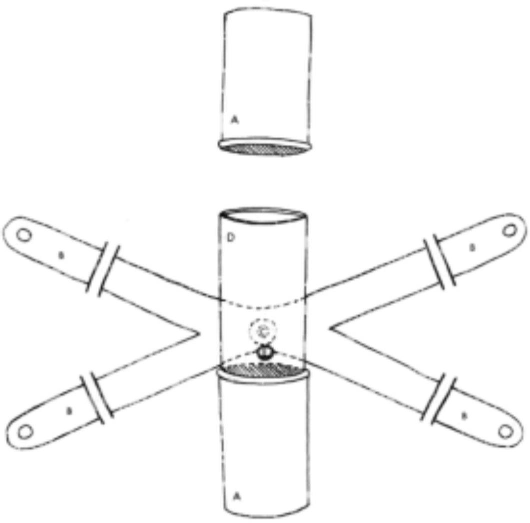

Figure 3. Construction of Backpack and Harness; A: Plastic film canisters; B: Leather straps; C: Metal rivet; D: Clear plastic tubing; E: Hole for exit of leads.

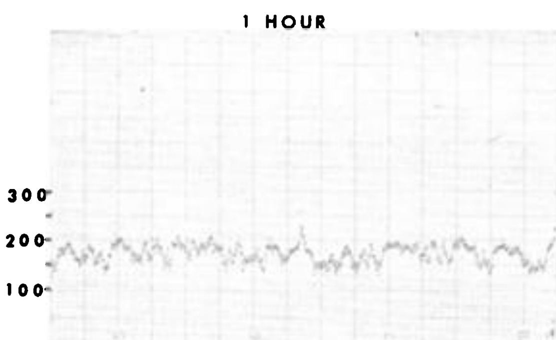

Figure 4. Heartrate data (heartbeats/min) obtained from a captive Red-tailed Hawk (*Buteo jamaicensis*) at a distance of 15 m.

The reference lead, if anchored in any area but the surface of dorsal muscles, did not provide adequate grounding for a proper response of the system. Interference by the electromyogram of the pectoral muscle tissue was assumed to have prevented satisfactory ventral placement of this lead, since difficulty was encountered only when that muscle was contracting. Obviously, this would be unacceptable in applications involving birds in flight. The method described might possibly be used to monitor the heart rate of birds in flight, however, given the lack of electromyogram interference and range of signal transmission.

Construction of the backpack/harness assembly was very simple and economical. Total cost was under $1 US. The plastic materials utilized endured the efforts of the birds to remove or dismantle them with beak or talon without contributing excessive mass. A very snug fit is required to prevent the bird from gaining access to the leads where they exit the dorsal incision and enter the backpack.

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