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TRANSMITTER IMPLANTATION TECHNIQUES IN BLACK RAT SNAKES

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ABSTRACT

Use of radiotelemetry has become common in the study of snakes, yet there exist few reviews of techniques for attachment of transmitters to snakes. We describe surgical techniques used to implant transmitters into black rat snakes (*Elaphe o. obsoleta*). Transmitters were implanted intraperitoneally and antennas were placed subcutaneously. We compare our methods to those used by others on this and other snake species, and discuss advantages and disadvantages of various techniques. We feel our methods provide an adequate approach for most radiotelemetric field studies of snakes.

INTRODUCTION

Herpetologists using radiotelemetry have taken three major approaches in introducing transmitters to snakes: 1) force-feeding, 2) external attachment, and 3) surgical implantation. While biologists have had success with all three approaches, drawbacks with the first two have led most researchers to use surgical implantation. Accordingly, in this paper we focus on implantation techniques. We initially based our techniques on methods described by Reinert and Cundall (1982) and Weatherhead and Anderka (1984), and subsequently made minor modifications. Recently, Reinert (1992) has provided a fine review of implantation techniques and field methods. However, some experimentation and information has remained unpublished, so in discussing our results, we draw on unpublished results of others. We emphasize that the appropriateness of techniques may vary with snake species and size.

METHODS AND RESULTS

Over a two-year period we performed 36 operations on free-ranging black rat snakes captured in western Arkansas, U.S.A. All procedures were conducted under protocol #A1482 reviewed by the Institutional Animal Care and Use Committee at University of Arkansas, Fayetteville. We implanted 31 transmitters, removed six, and released 25 snakes to radiotrack in the wild in 1992 and 1993.

We used two models of transmitters: 1) Holohil Systems Ltd. model #SI-2T, which measured 60 mm by 10 mm with a 27-cm antenna, and 2) Wildlife Materials Inc. model #LPB 2300 LDA, which measured 40 mm by 12 mm with a 20-cm antenna. Snakes used for implantation were 20 males and 10 females measuring between 71 and 152 cm snout-vent length (SVL), and weighing between 105 and 1300 g.

Implantation procedures: Procedures required two people: one to hold the snake while the other performed the surgery. All surgical instruments and the transmitter were immersed in 95% ethyl alcohol before and during the procedure, and general aseptic conditions were maintained. The snake was first weighed in order to calculate the amount of anesthetic needed. We used ketamine hydrochloride (Ketaset, 100 mg/ml; Aveco Co. Inc., Fort Dodge, Iowa), an injectable anesthetic, at a dosage of 80-100 mg/kg. Ketamine hydrochloride is a dissociative drug, safe and effective at a wide range of dosages across a variety of animal taxa. For many reptiles, dosages of 20-60 mg/kg will be adequate, although moderately higher dosages should be safe (Frye 1991). Smaller snakes may need relatively higher doses than larger snakes (Fraser 1991, Frye 1991). We injected the drug intramuscularly at four equidistant locations along the length of the body, avoiding the region of the heart. Refrigerating the snake before injection will slow its movement and lessen the risk of injury to snake or surgeon during injection, but will also slow action of the anesthetic.

Once the snake was immobile, we measured from the cloaca 1/4 the distance anterior to the snout to establish our incision site. With a #11 scalpel we made a 1-cm incision through the skin, diagonally between the scales, starting a short distance dorsolateral from the ventral scutes. We then incised underlying muscle with scalpel and fine scissors until reaching the peritoneal cavity. Mosquito hemostats may be used to hold back flaps of skin, and to squeeze tissue to stop any blood flow that may occur. Stiptic sticks may also be used to stop blood flow, and cotton applicators or absorbent cloth should be available. Once the peritoneal cavity is reached, hemostats may be used to stretch muscles around the opening; as much as possible cutting should be minimized and stretching maximized. In most cases cutting one or two ribs with rib-cutting scissors (similar to suture or nail-cutting scissors) is desirable, so as to ease introduction of the transmitter. Inserting a small metal spatula into the opening, we cleared away fascia posterior to the incision several cm, to create a pocket for the transmitter. The bends of the small intestine were visible inside the body cavity, and movement of the spatula should be gentle to avoid damaging internal organs. When the opening was wide enough, we carefully inserted the transmitter, keeping the antenna side lateral. We gently pushed the transmitter 2 cm posterior from the incision, so as to minimize risk of abrasion, which could cause the incision to reopen during recovery.

We inserted the antenna anteriorly between skin and muscle layers. To do this we used a 14-gauge stainless steel trochar with a custom-machined blunt end. The trochar was pushed, blunt end first, anterior from the incision subcutaneously. The antenna was inserted into the trochar, and a tiny incision was made through the skin at the blunt end of the trochar. The trochar was excised through this slit, leaving the antenna stretched out straight beneath the skin (Fig. 1). With a 15-cm trochar this step must be repeated twice, but can be accomplished in a single step with a 30-cm trochar.

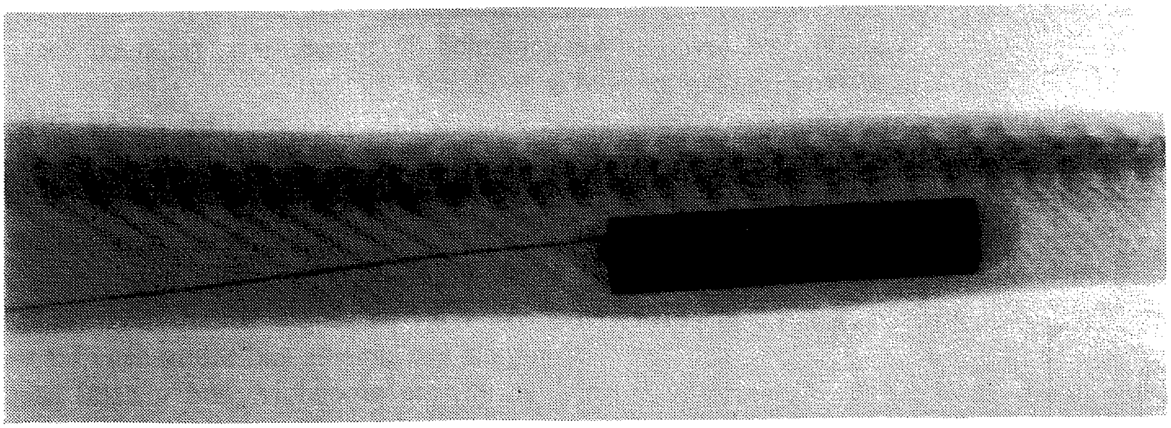

Fig. 1 X-ray of a transmitter implanted in a black rat snake.

We sutured the primary incision with chromic gut (4-0 with curved FS-2 needle; Ethicon Inc., Somerville, N.J.), using three surgeon's knots on the muscle layer and two on the skin, again between the scales. Sutures were sewn inward and then outward, leaving the layers slightly everted, since reptile skin tends to invert during healing (Frye 1991). We used separate sutures so as to minimize risk of post-operative rupture of the incision. The incision made for the trochar should be small enough so as not to require suturing. The incision site was then cleansed with alcohol and daubed with a topical antibacterial ointment (Polysporin or Neosporin). The entire surgical procedure, after reaching acceptable depth of anesthesia, generally took 25-30 min.

For recovery, the snake was placed in a clean 10-gallon aquarium with heating supplied. We monitored recovery and healing twice daily for 3-6 days before releasing the snake into the wild at the capture site.

Implantation results: All but one of our 31 snakes survived the procedures and healed successfully. The single mortality occurred during recovery in the smallest individual we operated on, a 71-cm SVL female. We were unable to determine cause of death, but speculate that respiration may have been hindered by the necessity of placing the transmitter further anterior in the snake's small body.

Nearly all surgeries went smoothly, despite two potential hazards. The first is unpredictable response of the snake to anesthesia. Individuals responded differently to identical dosages, and a few exhibited excessive movement during the operation. This problem, when it occurred, was alleviated by administering a second injection of anesthetic (at one-half or less of the main dose). The second hazard was blood flow from either skin or muscle layers, which occurred to some extent in slightly more than half of the operations. In all cases blood flow could be stopped by temporary pressure from hemostats, although in a few severe cases 2-3 min. of sustained pressure was necessary.

We used a trochar 15 cm in length to insert antennas of 20 and 27 cm. This necessitated cutting two slits and passing the trochar through twice, laying down one-half of the antenna each time. We did this so as to minimize risk of sudden movement by the snake during trochar insertion resulting in damage to skin, trochar, or antenna. However, this method often caused antenna kinking. These kinks are permanent and may stretch the skin. In a few cases this resulted in the distal half of the antenna protruding from the skin. Thus, providing the snake can be kept reliably still during the operation, we recommend using a longer trochar to lay down the antenna in a single action.

Recovery times varied greatly among snakes, with some becoming fully active immediately following surgery, and some taking three days to recover normal movement. Recovery time did not correlate with size, sex, or any other variable we measured. In two of the four cases in which snakes implanted with transmitters were kept in the lab for several months, the transmitter slid posteriorly most of the distance to the cloaca. This did not seem to interfere with digestion or defecation, however, and we did not observe this in any of the snakes released into the wild.

Health of implanted snakes in the wild: Observations of snakes in the wild for up to 24 months indicated they were behaving actively, climbing trees, using a variety of retreat sites, and foraging successfully (Withgott and Amlaner, this volume). By measuring and weighing snakes recaptured for transmitter removal, we confirmed that snakes were able to eat and grow. We had no indication that digestion or defecation were hindered by the presence of a transmitter along the length of the small intestine. Incision sites on some snakes healed to become undetectable, while in most small scars were visible but inconspicuous. In no snakes did the incisions reopen or become infected. Several of our snakes were captured by predators, but in only one case did we have reason to believe that transmitter implantation contributed to the death. This involved a snake captured, operated upon, and released in early November. After spending winter in a hibernaculum below ground, it seemed lethargic and weak in the spring, and spent an inordinate amount of time basking and exposed. In June it was taken by a predator, possibly due to its exposure. Rudolph (pers. comm.) has observed similar behavior in canebrake rattlesnakes (*Crotalus horridus atricaudatus*) implanted and released late in autumn.

Transmitter removal procedures: A long-term radiotracking study of wild snakes requires recapture of snakes and replacement of transmitters, at intervals dependent on battery life. We removed transmitters from six of our snakes. In each of these procedures, we made a new incision at the site of the posterior end of the transmitter, so that transmitter and antenna could be pulled out smoothly and in one piece. Fascia may surround and cling to the transmitter; once it is cut through neatly and carefully at the transmitter's posterior end, the transmitter should slip out easily. As soon as the base of the antenna is in view it should be gently seized with a smooth blunt hemostat so as to relieve pressure from the joint of the antenna and body of the transmitter, where stress breakage can occur. The incision is closed as described above. While our two-year study did not involve replacement of transmitters, we did so with one snake, by inserting a new transmitter through and immediately posterior to the incision made for the removal of the old transmitter. The trochar and antenna should be run either dorsally or ventrally of the old incision site, to avoid any scar tissue that may remain from the original implantation surgery. All operations to remove transmitters were successful, and all snakes recovered without complication.

DISCUSSION

For the vast majority of snakes, we feel surgical implantation to be superior to either force-feeding or external attachment. Ciofi and Chelazzi (1991) tracked the racer *Coluber viridiflavus* in Italy by attaching transmitters externally through the skin of the tail. However, external attachment may risk injuring a snake as it crawls through soil or rock crevices. Even if a snake can sense the transmitter on its body and avoid tight locations, such avoidance represents alteration of natural behavior. In addition, external attachment exposes the antenna to damage and may cause the transmitter's epoxy coating to wear away, causing transmitter failure.

Force-fed transmitters may be regurgitated or defecated, thus severely shortening tracking duration. They may also simulate a meal and thereby alter the snake's natural behavior (Lutterschmidt and Reinert 1990). In addition, it is difficult to use long antennas on force-fed transmitters, which decreases the range at which a snake can be located. For certain types of snakes, however, this technique may work. Greene (1986) and Greene and Santana (1983) force-fed transmitters to fer-de-lances (*Bothrops asper*) and bushmasters (*Lachesis muta*), large tropical ambush hunters. These snakes were large enough that transmitters did not simulate meals and inactive enough that relocation was not a problem (Greene, pers. comm.).

Any biologist surgically implanting transmitters should modify established techniques to suit the species he or she is working with, and should adjust methods according to his or her own experience and preferences. The techniques we describe may be modified for snakes that vary from rat snakes in taxonomic identity, size, behavior, or ecology. We expect surgical implantation of the transmitter in the peritoneal cavity and subcutaneous placement of the antenna, as detailed in this paper, to work well with most snakes of moderate or large size (> 85 cm SVL). Our results support the findings of Reinert (1992 and pers. comm.), who has implanted more than 170 snakes of 12 species using coelomic transmitter placement, without a single mortality, and has radiotracked individuals up to nine years in the wild. Placing the transmitter body subcutaneously, as done in black rat snakes by Weatherhead and Anderka (1984), can lead to abrasion of the skin where the bulge occurs, and to possible rupturing at the incision site. Weatherhead (pers. comm.) has since shifted to intraperitoneal implantation due to abrasion problems with rat snakes and massasauga rattlesnakes. However, Rudolph (pers. comm.) has implanted transmitters subcutaneously in several other crotalid and colubrid species without such problems.

Implantation of transmitters into small snakes (<< 1 m SVL) is certainly possible, but should be undertaken with caution. If transmitters are placed intraperitoneally, then they probably should be located further anterior than described in our methods, so as to utilize the widest area of the snake's body. However, the transmitter should not be so far anterior that it touches the lung and interferes with breathing. By placing transmitters subcutaneously and ventrally, Rudolph (pers. comm.) was able to operate on copperheads, rattlesnakes, and pine snakes of 51-87 cm total length (SVL plus tail length), with one mortality in seven surgeries. Subcutaneous transmitter placement may therefore allow for successful tracking of small snakes, provided their skin is pliable and strong enough to avoid damage by stretching and abrasion.

We recommend one major improvement upon our anesthesia methods. Use of volatile inhalant anesthetics such as halothane and isoflurane is preferable to injectable anesthetics such as ketamine hydrochloride, since volatile agents provide improved control over depth of anesthesia and enable rapid recovery following surgery (Frye 1991). Snakes under volatile anesthesia are kept limp and motionless (Weatherhead, pers. comm.), while under ketamine hydrochloride they retain some muscle function. With halothane or isoflurane, a snake's head is placed in a compartment into which the anesthetic is piped (usually at a 3-4% concentration). The volatile agent may be used to directly induce anesthesia, or ketamine hydrochloride may be used as an initial inducer. Using nitrous oxide in combination with the primary volatile anesthetic may allow a smoother and more rapid induction of anesthesia, and reduces the amount of primary anesthetic necessary (Frye 1991). Induction with halothane in black rat snakes took 15-20 min. for Durner and Gates (1993), and post-operative recovery times for a variety of snakes average roughly 20 min. for isoflurane and 30 min. with halothane (Reinert, pers. comm.).

With ketamine, recovery time varies among individuals; recovery times in our snakes (all given identical dosages based on body weight) ranged from 1 hour to 3 days, a range similar to that reported in the literature (Fraser 1991). Likewise, depth of anesthesia and retension of muscle function were variable and unpredictable. Since ketamine hydrochloride is processed by the kidneys, variability in renal efficiency among individuals may contribute to variability in response to the drug. Its use in snakes with renal deficiencies is not recommended and could prove lethal (Driggers, pers. comm.).

While gas anesthesia provides greater predictability than injectable drugs, there are drawbacks. With gas, snakes may require respiratory assistance following surgery (Reinert, pers. comm.; Weatherhead, pers. comm.). In addition, halothane is not always effective with large snakes, and may cause fluid buildup in the lungs of black rat snakes and some other species (Reinert, pers. comm.). Using ketamine hydrochloride is easier and less expensive (10 ml of 100 mg/ml Ketaset is $15.00). While Reinert (1992) and Reinert and Cundall (1982) describe inexpensive methods of inducing gas anesthesia, those who desire to use anesthesia machines will invest approximately $750.00 for equipment, in addition to the cost of the gas. Thus, choice of anesthetic will be influenced in part by economic considerations.

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