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SHORT COMMUNICATION

Mortalities due to constipation and dystocia caused by intraperitoneal radio-transmitters in Eurasian lynx (*Lynx lynx*)

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Abstract Three lynx (*Lynx lynx*) were found dead following complications after a surgically implanted free-floating intraperitoneal radio-transmitter became lodged within the pelvic canal. Two yearling lynx died due to consequences following severe constipation as the transmitter compressed the colon. Both were emaciated, with no abdominal or intrapelvic fat, which allowed the transmitter implant to fit into the pelvic canal. An adult female lynx died of dystocia when the pelvic birth canal was blocked by the transmitter when parturition began, leading to uterine rupture and subsequent peritonitis. A total of 41 lynx were implanted with this type of intraperitoneal transmitter in Scandinavia in 1997–2002. After the three transmitter-associated mortalities, the transmitter type used in lynx cubs was exchanged for another model, and further fatalities due to the implants have not been documented.

Keywords Implant · Lynx · Mortality · Radio-transmitter · Wildlife

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Introduction

Intraperitoneal radio-transmitters are widely used for studying large carnivores such as lynx (*Lynx lynx*, Arnemo et al. 1999), wolverines (*Gulo gulo*, Persson et al. 2003) and bears (*Ursus arctos*, Arnemo et al. 2007) and are fundamental for the success of many wildlife research projects. There are several advantages of implantable compared to external transmitters, such as avoiding collar or harness pressure necrosis (Koehler et al. 2001), less change of behaviour (Garshelis and Siniff 1983), avoiding external equipment attachment difficulties (Hernandez-Divers et al. 2001) and enabling acquirement of physiological data. Abdominal implants give fewer complications than subcutaneous implants, as shown in Eurasian badgers (*Meles meles*, Agren et al. 2000) and North American beavers (*Castor canadensis*, Davis et al. 1984). When lesions or mortality arises due to human intervention in wildlife (e.g. by applying radio-transmitters), it is important to react promptly out of both ethical and animal welfare concerns. This short communication describes three cases of mortality in lynx directly linked to the use of an intraperitoneal transmitter.

Materials and methods

The cases were identified by searching the necropsy database at the National Veterinary Institute (SVA), Uppsala, Sweden, for a cause of death in lynx involving implanted transmitters. The implant type used in all three cases was Telonics®, IMP/150/L, weight 20 g, cylindrical shape 5.3 cm long and 2.3 cm in diameter, with a 6-month battery life at 40 pulses per min. Between 1997 and 2002, this transmitter type had been used in 41 animals in the Scandlynx Project (Scandlynx 2009). Surgical procedures in the three lynx were performed as described by Arnemo et al. (1999) for intraperitoneal implantation of radio-transmitters, at an estimated age of 6–8 weeks, when the average body weight was 1.7 kg. To avoid the stress of recapture and additional surgery, a decision was made to not remove the implanted transmitters after the batteries had expired (Arnemo et al. 1999).

Results

The SVA database on lynx necropsies contained three cases where transmitters were involved as a cause of death. The first case was a female yearling lynx about 8 months old. The transmitter had been implanted in July 1999 in Örebro County (N 59°, E 15°), and the lynx was found dead 6 months later in the same county. At necropsy, the body was emaciated and weighed 7.0 kg. The stomach and small intestine were markedly dilated by copious amounts of red-brown watery fluid, and there was petecchial haemorrhage in the gastric mucosa. The abdominal part of the large intestine was severely dilated and filled with abundant firm faecal material, anterior to the pelvic canal. The transmitter was found within the pelvic canal where it compressed the intrapelvic section of the colon and the rectum, causing constipation. There was no fibrous capsule surrounding the transmitter. Cause of death was emaciation and circulatory collapse as a consequence of the advanced constipation caused by the radio-transmitter completely obstructing the colonic passing of faecal matter.

The second case was a yearling male lynx about 9 months old. The animal was implanted with a transmitter in June 2001, also in Örebro County, and was found dead 8 months later in the same county. At necropsy, the carcass was emaciated, with severe muscle atrophy, and weighed 7.4 kg. The transmitter was found in the pelvic canal (Fig. 1a) compressing the colon. There was marked dilation of the abdominal part of the large intestine, which was filled with brown, firm faecal material proximal to the transmitter (Fig. 1b). The colon wall adjacent to the transmitter was darkly discoloured and necrotic. A perforation of the intestinal wall (Fig. 1b) had led to leakage of intestinal contents into the abdominal cavity, resulting in a marked suppurative peritonitis which was considered the ultimate cause of death. There was no fibrous encapsulation of the transmitter, which was easily extracted from the pelvic canal at necropsy (Fig. 1b).

The third case was a 6-year-old female lynx found dead in May 2006 in Västmanland County (N 59°, E 15°). The intraperitoneal transmitter had been implanted when the lynx was about 8 weeks old, in the same county. At necropsy, body weight was 15.8 kg, and body condition was slightly below normal. The female was giving birth to two full-term kittens when she died. Both kittens were macerated, indicating in-utero death at least several days before the female died. One kitten was found in a normal birthing position, with head first in the birth canal, partly within the open cervix (Fig. 2). The radio-transmitter was lodged entirely within the pelvic canal, adjacent to and compressing the cervix and vagina, and thereby limiting the diameter of the birth canal. The transmitter was not enclosed in a fibrous capsule. The second kitten was still within a uterus horn. The uterus was generally severely oedematous and congested, and there was a 1.5-cm linear intravital rupture with haemorrhage along the rupture edges. The peritoneum and serosal surfaces of abdominal organs were congested and covered in fibrinoid flocculent material and green and red-brown-discoloured exudates. The cause of death was determined to be peritonitis following dystocia, with uterine rupture secondary to the transmitter lodging within the pelvic canal.

Discussion

The three mortalities can be attributed to an intraperitoneal radio-transmitter lodged in the pelvic canal, causing mechanical obstruction and constipation or dystocia. This is the first reported case of an abdominal transmitter negatively interfering with pregnancy and parturition in a mammalian species. The cylindric transmitter had a diameter only slightly smaller than the pelvic canal internal measurements. The two yearlings must have had very little or no abdominal fat reserves to allow the transmitter to enter the pelvic canal. Comparisons at necropsy of young lynx in good body condition showed that a transmitter with a diameter of 2.3 cm cannot be introduced into the pelvic canal, as fat tissue limits the available pelvic canal space.

Other cases of negative mechanical effects of abdominal transmitters are reports of a North American beaver (*C. canadensis*, Guynn et al. 1987), a silver fox (*Vulpes vulpes*, Moe et al. 1995) and an American badger (*Taxidea taxus*, Quinn et al. 2010). These animals died due to abdominal adhesions involving the transmitter and intestines. Arnemo et al. (2007) reported findings in brown bears (*U. arctos*) 3–

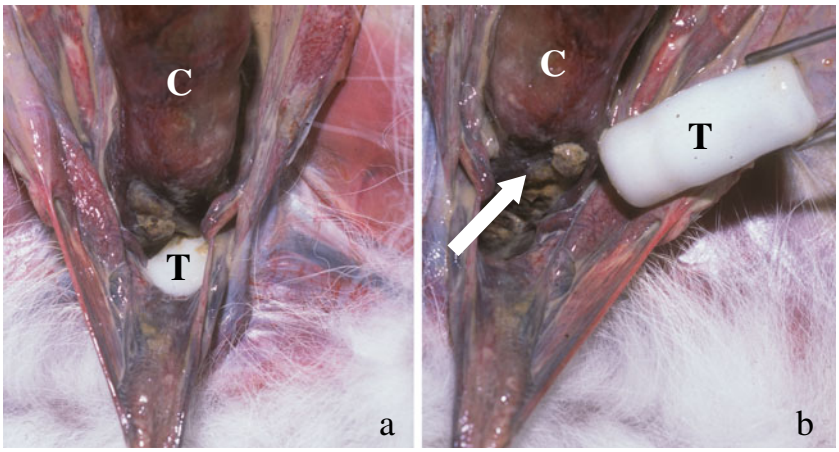

Fig. 1 **a** Yearling male lynx necropsy. Close aspect of cranial pelvic aperture in the dorsal positioned body, showing the transmitter (*T*) located in the pelvic canal and marked distention of the colon (*C*). **b** The transmitter was not encapsulated and was easily removed from the pelvic canal. Close to the transmitter, there is dark discoloration and necrosis of the colon wall, and an intralesional perforation with leakage of intestinal contents (*arrow*)

9 years after implantation, where 50% of the implants were encapsulated in the omentum and surrounded by connective tissue. Bacterial cultures of samples from the capsule and the surface of the implant showed no bacterial growth, and the localized reactions appeared not to have affected the animals. This aseptic tissue response can be explained by local mechanical friction and foreign body reaction. So far, the implants do not seem to elicit a tissue reaction in lynx. There was no reaction to implants recorded at the necropsy of two juvenile lynx found dead 3.5 months after surgery or in three other lynx from the Scandlynx project according to the SVA database. At a second surgery after 5 months to exchange the implant in four juvenile lynx, there were no lesions or reactions from the first surgery or from the implant noted (Arnemo et al. 1999). Studies using intraperitoneal implants in other species also show lack of notable reactions or pathology, such as beavers sacrificed 2–4 months after surgery (Davis et al. 1984), wolf cubs (*Canis lycaon*, Crawshaw et al. 2007) and sea otters (*Enhydra lutris*) from which transmitters were removed after 4 months (Garshelis and Siniff 1983).

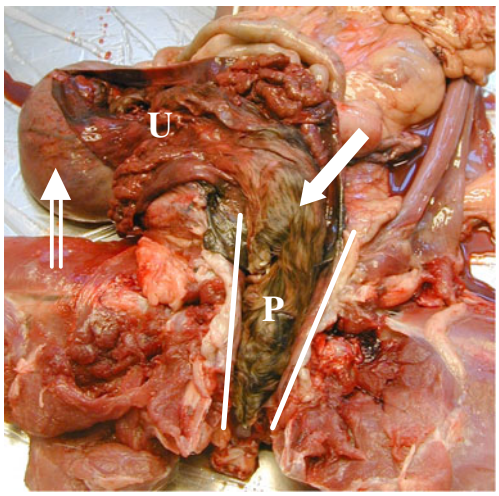

Fig. 2 Female lynx necropsy. Gross aspect of caudal abdominal area of the dorsal positioned body. The ventral pelvic bones are removed to show the pelvic canal (*P*). The uterus (*U*) is excised to show the macerated full-term kitten, partly in the pelvic canal (*arrow*). Dorsal to the uterus in the pelvic canal is the transmitter (not visible in figure), impeding the delivery of the kittens. A second kitten is located in the left uterine horn (*open arrow*) as is an intravital rupture of the uterus (not visible in figure)

We conclude that the size and shape of the implant caused the mortalities in the cases presented here. Since the mortalities due to transmitters were noted, Scandlynx researchers have replaced the Telonics® IMP/150/L implant with Telonics® IMP/400/L (95 g, 9.7×3.3 cm; Telonics 2009), and a total of 58 implantations have been carried out with the latter type from 1997 to 2011. No further mortalities attributed to transmitters have occurred (Scandlynx, unpublished). The internal length of the pelvic canal is about 6 cm in an adult female, with an oval cranial opening of about 4×5 cm, allowing the smaller transmitter model to fit completely inside the pelvic canal. As there was no constipation in the female, the transmitter could have been present in the pelvis for some time without obvious negative effects. Not until parturition started did the limited pelvic space cause dystocia and ultimately death.

Although the risk of recapture and additional surgery has to be considered, it can be favourable to change the transmitter model in growing kittens as a study on lynx in Norway has shown (Arnemo et al. 1999). Attaching the abdominal transmitter to the abdominal wall can prevent the implant from entering the pelvic canal and also make it easier to locate for removal (McKenzie et al. 1990).

Reproductive interference due to abdominal transmitters in a mallard duck (*Anas platyrhynchos*) has been reported by Korschgen et al. (1984), but previously no reproductive complications have been reported in mammalian species. Studies reporting reproductive data of animals with a radio

package in the abdominal cavity include North American river otters (*Lontra canadensis*, Reid et al. 1986; Hernandez-Divers et al. 2001) and yellow-bellied marmots (VanVuren 1989).

The female lynx in this case had previously given birth to a litter of two kittens in 2004 and a litter of three in 2005. Of all the 17 female lynx equipped with an intraperitoneal radio-transmitter in the study area, six are known to have reproduced successfully at least once. Six others died before the age of sexual maturity, while the reproductive success of the last five is unknown (Scandlynx database). Average litter size of these female lynx was 2.5 kittens, which is also the observed average litter size of female lynx marked only with collars, according to Scandlynx records.

In conclusion, these three fatal cases were caused by the transmitter entering and lodging within the pelvic canal, causing a mechanical obstruction of the large intestine in two yearling lynx and of the birth canal during delivery in one lynx. Further mortality caused by intraperitoneal transmitters ceased after change of transmitter type. The use of transmitters of a suitable size and shape do not appear to be harmful to lynx, which is important out of ethical and welfare concerns in work with wildlife conservation and research.

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