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Surgical treatment of injuries caused by fishing gear in the intracoelomic digestive tract of sea turtles

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ABSTRACT: We report the surgical techniques used to remove accidentally ingested hooks and branchlines localized in different parts of the digestive tract of 129 loggerhead sea turtles *Caretta caretta*, together with the characteristics and localization of lesions, and final outcome related to their severity. Hooks were removed from the cervical esophagus via the ventral surface of the neck, while the supraplastron approach was performed for hooks wedged in the intracoelomic portion of the esophagus. An approach through the left axillary region was preferred for fishhooks in the stomach, while hooks and long branchlines in the intestine or pyloric area were removed by approaching the coelomic cavity through the right or left prefemoral fossa. The ingestion of fishhooks, and/or longlines, often induces severe injuries in the digestive tract that could lead to the death of the turtles, with the extent of damage engendered by lines often more severe than that caused by hooks, leading to strangulation, intussusception, and tears that require resection of long tracts of intestine. Spontaneous expulsion of hooks, even where possible, involves long waiting times, with the possible impairment of the turtle's clinical condition, and should be avoided when the line is evident or suspected. The development of diversified surgical techniques enabled us to approach the coelomic cavity with minimally invasive and easy-to-perform methods, and survival rates proved very satisfactory.

KEY WORDS: Injuries · Fishing line · Digestive tract · Surgical treatment · Sea turtles

INTRODUCTION

Drifting longline is fishery gear used both in the Mediterranean basin and worldwide by commercial fishing fleets to catch swordfish *Xiphias gladius* and tuna species. It comprises a main line many kilometers long, to which hundreds of secondary lines (branchlines) are attached, each carrying a baited hook (Casale et al. 2008). However, non-target species, including endangered large marine vertebrates (cetaceans, sharks, and sea turtles), can accidentally become entangled or hooked in such gear (Heppell et al. 1996, Tomas et al. 2001, Lewison et al. 2004, Casale et al. 2008). Loggerhead sea turtles *Caretta caretta* are among the most frequent bycatch victims of drifting longlines (Camiñas & De la Serna 1995, Laurent et al. 2001, Lewison et al. 2004, Camiñas et al. 2006, Casale et al. 2008), which are a major anthropogenic mortality factor for this vulnerable species in the Mediterranean (Gerosa & Casale 1999, Casale et al. 2008).

Accidentally ingested fishing hooks are more frequently lodged in the oral cavity or in the cervical esophagus (Orós et al. 2004, Di Bello et al. 2007, Casale et al. 2008). In these situations, displacement can be attempted with dehooking devices, or with the PVC pipe technique (Jaeger et al. 2003). Otherwise, in most circumstances, it is more advisable to plan for surgical esophagotomy by approaching the cervical portion of the esophagus from the ventral

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surface (Di Bello et al. 1994, 2001, Hyland 2002, Moraes-Neto et al. 2003), a quick and easy technique to perform.

On the other hand, a non-negligible percentage of cases present with very severe lesions due to interaction with longlines, either in the more distal sections of the gastrointestinal tract or on external parts of the body. In fact, fishermen often release bycatch sea turtles back into the wild with the ingested hook after cutting the branchlines. Unless the line is short enough (i.e. a few centimeters from the hook), it can easily become entangled around the flippers, causing injuries such as ischemia, necrosis, and limb loss (Schofield et al. 1998, Di Bello et al. 2007). Otherwise, the branchline can be ingested and extend to the gastrointestinal tract while the hook is lodged in the oral cavity or in the esophagus, or else can follow the movement of dislodged hooks along the intestine. In such cases, the branchline can extend along the entire gastrointestinal tract and exit via the cloaca, while hooks can wedge in the stomach or intestine walls. In such circumstances, peristalsis can cause traction, plication, intussusception, tearing, and necrosis of gastrointestinal walls, with subsequent death of the turtle (Orós et al. 2004, Di Bello et al. 2006, Valente et al. 2007, Casale et al. 2008).

This paper reports the surgical techniques used to remove accidentally ingested hooks and branchlines from drifting longlines localized in different parts of the digestive tract of loggerhead sea turtles *Caretta caretta*, together with the characteristics and localization of lesions, and final outcome related to their severity.

Table 1. Localization of hooks and lines in the loggerhead sea turtles observed. R: released; D: died

Gear localization		No. of	Outcome	
Hook	Line	cases	R	D
Oral cavity	Intestine	2	2	–
Cervical esophagus	Intestine	48	37	11
Intracoelomic esophagus	Intestine	7	4	3
Stomach	In/out of mouth	30	30	–
Stomach	Intestine	8	5	3
Intestine	Out of mouth and/or cloaca	10	10	–
Multiple hooks	Out of mouth and/or cloaca	4	4	–
None	Out of mouth and/or cloaca	20	12	8

MATERIALS AND METHODS

Between January 2006 and October 2011, 129 loggerhead sea turtles *Caretta caretta* were referred to the authors because of accidentally ingested fishing hooks and lines; 126 underwent surgery for the removal of hooks and lines derived from drifting longlines, localized in the intracoelomic part of the gastrointestinal tract (distal esophagus, stomach, intestine) (Table 1). Eighty-eight animals were brought to the World Wildlife Fund (WWF) Rescue Center of Lampedusa (Italy), 34 to the Veterinary Surgery Section at the Faculty of Veterinary Medicine in Bari (Italy) followed by referral to local sea turtle rescue centers, and 7 to the 'Archelon' Sea Turtle Rescue Center in Glyfada (Greece). Most of the animals were referred to rescue centers by volunteers, having been found either drifting at sea or stranded along the coasts; in some cases, fishermen who had found the animals caught in drifting longlines brought them to the centers.

Upon admission, each turtle was given a medical examination, with an ensuing report on its biometrics, clinical conditions, and diagnostic test results: curved carapace length notch-to-tip ranged from 28.0 to 73.2 cm (mean ± SD, 52.1 ± 9.89 cm), curved carapace width was 24.5 to 72.0 cm (48.3 ± 10.55 cm), and weight was 2.3 to 39.0 kg (15.8 ± 8.86 kg).

On clinical evaluation, 81 turtles had the tip or a loop of a branchline coming out of their mouth or cloaca or both (Fig. 1). After dorsoventral (vertical), lateral (horizontal) and craniocaudal (horizontal) X-ray examinations, 109 turtles showed one or more hooks lodged in various areas of the digestive tract. Of these, 2 (1.8%) turtles had a hook wedged in the oral cavity, 48 (44%) in the cervical esophagus, 7 (6.4%) in the intracoelomic part of the esophagus close to the bronchial bifurcation, 38 (34.9%) in the stomach, 10 (9.2%) in various tracts of the small intestine, while the remaining 4 (3.7%) had 2 or 3 hooks in various portions of the digestive system (Table 1, Fig. 2).

In 46 of these animals, radiographs were repeated every other day in order to assess whether spontaneous progression and expulsion of the hook along the gastrointestinal tract was ongoing. Of 48 turtles presenting with lines coming out of their mouth or cloaca, 15 were in poor clinical conditions, so surgery was performed as soon as possible to remove hooks and lines.

Different anesthetic protocols were used for surgery, depending on the clinical condition of the turtle and the local availability of suitable equipment. Some animals were induced with 40–60 µg kg^{-1}

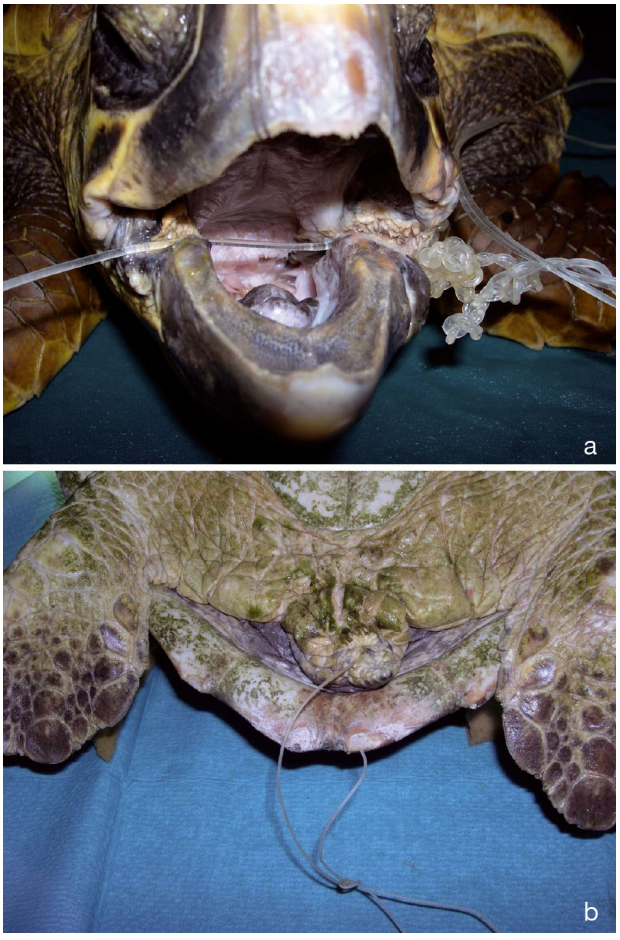

Fig. 1. Sea turtle with a loop of branchline coming out of the (a) mouth and (b) cloaca

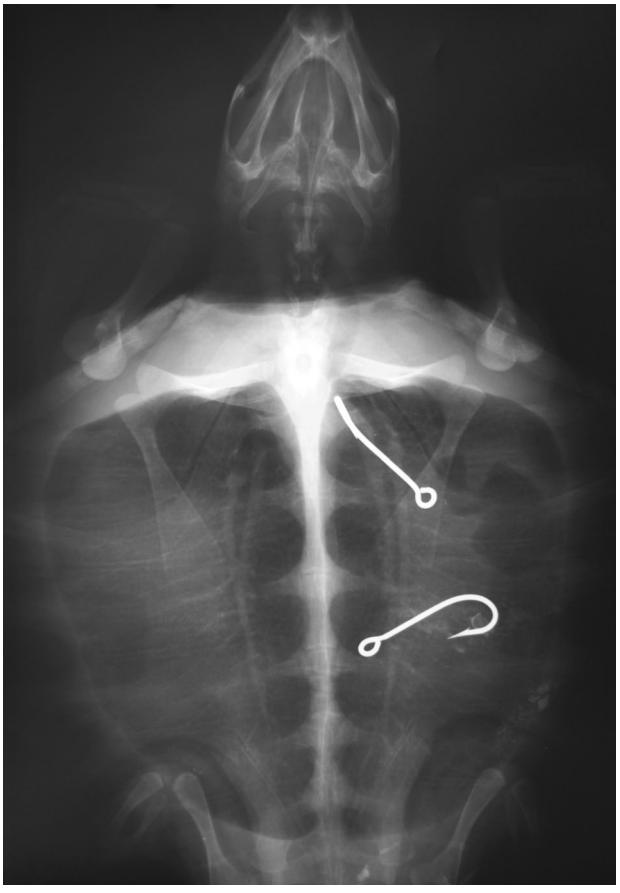

Fig. 2. Dorsoventral radiographic projection of a loggerhead sea turtle with 2 fishing hooks lodged in different districts of digestive system: one is at the end of intracoelomatic oesophagus and the other in the pyloric region of the stomach

medetomidine and 5 mg kg^{-1} ketamine intramuscularly (IM), whereas most were induced with 3–5 mg kg^{-1} propofol intravenously (IV) in the cervical venous sinus, sometimes preceded by premedication with 40–60 µg kg^{-1} medetomidine IM 10 to 15 min before propofol administration. Depending on the protocol used, 10 to 20 min after induction, the turtles were intubated with an uncuffed endotracheal tube of suitable size. Maintenance of anesthesia was achieved with oxygen and sevoflurane 3–5% (Veterinary Surgery Section at the University of Bari) or isoflurane 3–5% (Lampedusa Sea Turtle Rescue Center and Glyfada Sea Turtle Rescue Center). A non-rebreathing circuit and manual ventilation were used, with 10 to 15 breaths per minute until a surgical anesthetic plane was achieved, and thereafter 3 to 5 breaths during maintenance anesthesia.

Once the turtle was correctly anesthetized, it was placed in dorsal recumbency and the surgical site was aseptically prepared according to the most appropriate approach, which varied according to hook position and/or presence of lines (Table 2).

For the extraction of fishhooks lodged in the stomach, an approach to the coelomic cavity through the soft tissues of the left axillary region was generally preferred (Di Bello et al. 2006).

Hooks wedged in the caudal coelom and long branchlines located in wide tracts of (or even throughout) the intestine were removed via an inguinal incision into the coelomic cavity through the soft tissues of either the right or left prefemoral fossa (Brannian 1984, Gould et al. 1992, Di Bello et al. 2006); a left approach was also preferred for the removal of fishhooks stuck in the pyloric area of the stomach.

In some circumstances, an inguinal approach to the coelom was required after removing hooks from the esophagus or stomach via the corresponding approaches, because of the presence of branchlines,

Table 2. Summary of the 126 surgical cases, according to approach, hook/line localization and outcome. A: axillary; P: prefemoral; C: cervical; SP: supraplastron; M: mouth; E: esophagus; S: stomach; I: intestine; R: released; D: died

Approach	No. of cases	Hook localization						Line only	Outcome	
		M	E	S	I	E+S	E+I		R	D
A left	25	–	–	24	–	–	–	1	25	–
P right	22	2	–	–	7	–	–	13	15	7
P left	11	–	–	3	2	–	–	6	10	1
C + A left	3	–	–	–	–	3	–	–	3	–
C + P right	31	–	31	–	–	–	–	–	25	6
C + P left	18	–	17	–	–	–	1	–	13	5
SP + P right	7	–	7	–	–	–	–	–	4	3
A left + P right	9	–	–	8	1	–	–	–	6	3
Total	126	2	55	35	10	3	1	20	101	25

discovered intraoperatively, connected with the hooks and extending along the intestine.

Hooks lodged in the cervical esophagus were removed by approaching the esophagus from the ventral surface of the neck with a longitudinal right paramedian incision (Di Bello et al. 1994, 2001, Hyland 2002, Moraes-Neto et al. 2003). When the hook was wedged in the intracoelomic portion of the esophagus, the supraplastron approach was performed as described by Jaeger et al. (2003), via a 5 to 7 cm transversal incision at the junction of the cervical skin and the cranial edge of the plastron.

In both cervical and intracoelomic esophagotomy, the esophageal wall was closed with 2-0 or 3-0 coated braided polyglactin 910 suture in a continuous inverting pattern, followed by simple interrupted sutures with 2-0 or 3-0 monofilament polypropylene as reinforcement.

When gastrotomy was performed, the stomach wall incision was closed with 3-0 monofilament polyglecaprone suture in a simple continuous pattern for mucosa and submucosa, followed by 2-0 or 3-0 coated braided polyglactin 910 suture in a continuous inverting pattern for muscularis and serosa.

Single or multiple enterotomies for removing hooks and lines in long tracts of intestine were closed with 3-0 monofilament polyglecaprone or 3-0 coated braided polyglactin 910 sutures in a double-layer continuous inverting pattern. If the intestinal wall appeared edematous or considerably thickened, a coated braided polyglactin 910 suture in a single-layer Ford continuous interlocking pattern was preferred, followed by simple interrupted sutures as reinforcement.

Intestinal tears, frequently found as a consequence of traction, as well as ischemia and necrosis of the walls subjected to plication and constriction due to line tightness, were treated by margin debridement and 3-0 monofilament polypropylene suture in a single-layer continuous inverting pattern. In some cases, the intestinal wall was severely damaged by branchline constriction, so a more or less extended segment had to be resected; end-to-end anastomosis was performed with 3-0 coated braided polyglactin 910 or 3-0 polypropylene sutures in a double-layer simple interrupted pattern. Before repositioning, the exteriorized intestine was repeatedly cleaned with warmed sterile saline in order to remove debris from wall tears during surgery. As much as possible, the coelomic cavity was also cleaned with warmed sterile saline, by means of repeated irrigations and aspirations.

Regardless of the approach used, in all turtles, the coelomic membrane and muscle layers were closed with 2-0 polyglactin 910 or polyglecaprone 25 suture in a simple interrupted suture pattern; the same suture material was used to close the subcutaneous tissue, whereas the skin was sutured with 2-0 polypropylene monofilament in an interrupted suture pattern (Di Bello et al. 2006).

Approximately 20 min before the end of the surgical procedure, administration of the anesthetic gas was discontinued, and the turtle was allowed to breathe 100% oxygen. At the end of surgery, the turtle was placed in ventral recumbency and ventilated with air until extubation and full recovery. In turtles that had received medetomidine as premedication or induction agent, atipamezole (200 to 300 µg kg^{-1} IM) was administered to aid recovery from anesthesia.

After surgery, each turtle was rehydrated with lactated Ringer's solution, saline solution, and 5% glucose solution (20 ml kg^{-1} d^{-1}) administered IV or into the coelomic cavity for 2 d to 1 wk, according to clinical conditions. Enrofloxacin (5 mg kg^{-1} subcutaneously after dilution, every 24 h) was administered for 10 d, and ranitidine (300 µg kg^{-1} IM, every 24 h) for 7 d.

RESULTS

Only 3 turtles out of the 46 periodically monitored for dislodgement of the hooks achieved spontaneous expulsion. On admission, the hooks were localized in the stomach lumen, and in subsequent X-ray exami-

nations they had migrated along the intestine until successful definitive expulsion 9, 18, and 20 d, respectively, after the first assessment. As the remaining 43 turtles showed no displacement of the hooks during the 7 to 10 d following initial assessment, they underwent surgery to remove them.

Left axillary approach

In 24 out of 25 turtles that underwent surgery with the axillary left approach, the surgical procedure consisted merely of the removal of hooks lodged in the stomach wall without complications relating to branchlines; in fact, some lines came out of the mouth and so could easily be removed after cutting off the hook, or were too short to engage the digestive tract and, therefore, could not act as a linear foreign body. In the 25th turtle, the axillary approach was required in order to remove a great tangle of thin fishing line filling most of the stomach lumen and coming out of the mouth. These turtles were all in satisfactory clinical condition, began to feed voluntarily in 4 to 7 d, and were released into the wild after a short rehabilitation period.

Right inguinal approach

Among the 22 turtles in which an inguinal right approach was preferred, 2 presented with the hooks fixed in the oral cavity with lines coming out of the cloaca, and 13 showed lines coming out of the cloaca and/or the mouth but without hooks, a sign that the lines extended along all or most of the digestive tract. The remaining 7 presented with hooks in the intestine, localized in the right caudal portion of the coelomic cavity. The right inguinal approach facilitated exteriorization of intestinal loops, except in cases of severe plication, congestion, or edema. The lines were extracted through multiple small enterotomies along the anti-mesenteric curve, through which the line could be cut into small pieces and gradually removed until full distention of the intestinal tract had been achieved. Depending on the length of the fishing line, multiple (from 2 to 5) enterotomies were performed at regularly-spaced intervals along the exposed intestine. At each enterotomy site, the fishing line was cut, and each segment of line was extracted through the incision immediately proximal to the site until all of the line had been removed and the plication of the intestine had been completely resolved (Di Bello et al. 2006). In 14 cases, the traction of the linear foreign bodies had torn the intestinal wall to various extents, and the consequent severity of the damage required enterectomy of approximately 40 cm of ileum (Fig. 3) and subsequent end-to-end anastomosis in one turtle. Fifteen turtles were successfully released after a short rehabilitation period, while the remaining 7 died due to the severity of their injuries.

Left inguinal approach

In 11 cases, the left inguinal approach was preferred: 3 turtles showed a large hook in the pyloric region of the stomach and the branchline coming out of the mouth, while in 2 turtles the hook was in the intestinal lumen, in the caudal and left side of coelomic cavity, whereas the other 6 had long tracts of fishing line along a large portion of the digestive tract. In the 3 turtles presenting with the hook in the pyloric region, exteriorization of this section of the stomach using the left inguinal approach was quite easy: gastrotomy was performed at the site where the barb was lodged (Fig. 4), and when the lines were cut they were extracted through the mouth. In the remaining 8 turtles, exteriorization of intestinal loops in sequence, together with multiple minor enterotomies enabled the lines to be extracted as described above. Five of these turtles showed some damage to the intestinal wall, in 2 cases so severe as to require extensive enterectomy, and one of these animals died immediately after surgery. All the remaining turtles were released after full recovery.

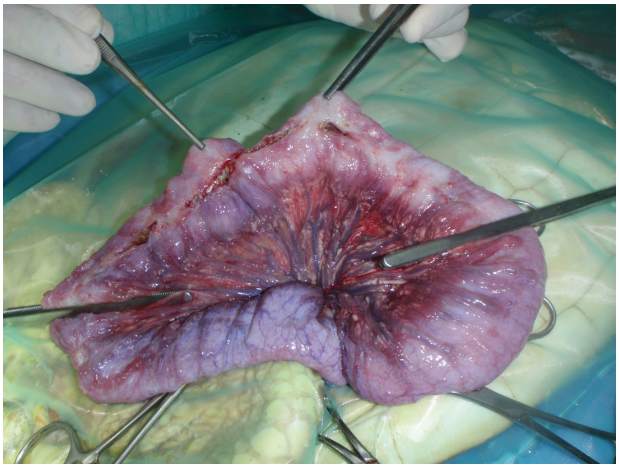

Fig. 3. Intraoperative photograph that shows the severe laceration of the intestinal wall caused by the persistence of the fishing line

Fig. 4. Exteriorization of the stomach to perform the extraction of a big hook piercing the gastric wall

Cervical approach + left axillary approach

In 3 turtles, both cervical approach to esophagus and left axillary approach to stomach were required in order to remove hooks lodged in both areas. In all 3 cases, there were no injuries other than those caused by the attachment of the hooks to the organ walls, as branchlines presented out of the mouth and were easily removed after dislodgement of the hooks. The favorable pre-surgical clinical conditions were followed by uneventful recovery and rapid release back to the wild.

Cervical approach + left or right inguinal approach

In 49 turtles, both cervical approach to esophagus and left or right inguinal approach to intestine were required. In some cases, the procedures were planned because of evidence of hooks in the esophagus and lines coming out of the cloaca at admission; in others, the presence of lines slipping in the digestive tract was detected during hook removal from the esophagus, and their removal using the cervical approach was regarded as impossible. In one turtle, the left inguinal approach was planned because of 2 additional hooks in the intestinal lumen. Sometimes, exteriorization of intestinal loops through the left inguinal approach proved to be complicated, owing to the strong line traction in the mesenteric side of the intestine. In such cases, cutting and removal of small tracts of the line through small enterotomies made it possible to progressively extract and extend the intestine. In 9 turtles, the intestinal wall proved to be damaged as a result of line traction, with several wide tears, which in one case required substantial enterectomy. Eleven turtles died soon after surgery; the remaining 38 were released after long rehabilitative periods (from 20 to 24 wk). During post-surgical rehabilitation, 25 subjects fed spontaneously while the other 13 required tube-feeding for 3 to 8 wk, until spontaneous feeding recommenced. The remaining weeks of rehabilitation before release to the wild were needed to regain a nutritional condition and appropriate weight for the size of the different animals.

Supraplastron approach + right inguinal approach

In the 7 turtles with hooks wedged in the intracoelomic tract of esophagus, which required the supraplastron approach according to Jaeger et al. (2003), the branchline engaged with the digestive tract, so the right inguinal approach was also required. In 2 cases, the extreme traction of the line made it impossible to remove the hook through the esophageal incision; in these cases, it was necessary to proceed initially with multiple enterotomies as described above to remove the line, thus reducing traction on the hook that was subsequently extracted together with the remainder of the line. All 7 turtles presented extensive tears in the intestinal wall, requiring reconstruction, which substantially prolonged surgery and anesthesia. After an appropriate rehabilitation period, 4 turtles were successfully released; the remaining animals died because of the severity of their lesions and poor clinical conditions. These 3 subjects were very emaciated and anemic and during surgery massive contamination of the coelomic cavity was found due to abundant fecal material from numerous bowel lacerations.

Left axillary approach + right inguinal approach

In the remaining 9 turtles, the contemporary presence of hooks in the stomach and lines in the intestine required both left axillary and right inguinal approaches. After gastrotomy to remove the hook and to cut off the connection with the line, assessment of the intestinal loops through the second approach revealed the presence of diffuse edema, congestion, and plication of extended tracts of the intestinal walls. Four turtles also had several tears, and in one turtle the severity of these injuries required the resection of approximately 35 cm of intes-

tine, with subsequent end-to-end anastomosis. Three of these turtles died within 72 h of surgery, while the remaining 6 were released to the wild after varying rehabilitation periods.

The most severe intestinal lesions were observed in subjects that had ingested thin fishing line (diameter 0.60 to 0.80 mm), while in the case of thicker lines (diameter 1.40 to 1.80 mm) the lesions observed were mostly edema and congestion of the intestinal walls.

In many cases, a massive inflammatory reaction developed at the site where the hook was embedded in the esophageal wall, especially in the caudal tract. Reactive granulomas, with fibrinous and necrotic tissues, embedded the hooks in large cystic masses, and often caused considerable obstruction of the esophageal lumen.

In 106 cases of hooks extracted from the digestive tract, 87 were J-shaped steel hooks 7.2 to 8.1 cm long and 3.3 cm wide mounted on lines with a diameter of 1.40 to 1.80 mm, essentially targeting swordfish *Xiphias gladius* and tuna species. In the remaining 19 cases, it was steel hooks 3.1 to 4.8 cm long and 2.1 to 2.6 cm wide mounted on lines with a diameter of 0.60 to 0.80 mm, used for fishing common dentex *Dentex dentex*, dusky grouper *Epinephelus marginatus*, and axillary seabream *Pagellus acarne*.

DISCUSSION

Various anesthetic protocols are described in this paper due to subsequent adaptations of initial premedication and induction techniques on the basis of the authors' ongoing experience. The ketamine-medetomidine association was progressively abandoned because of its undesirable side effects, such as cardiorespiratory depression and prolonged recovery time, which often proved unsafe, above all in critically debilitated turtles. By contrast, the use of propofol has always secured satisfactory anesthesia and rapid recovery times, thanks to its short half-life and safety. The choice of whether or not to use premedication with medetomidine was influenced by the general clinical conditions of the turtles, and induction with propofol only was preferred in critical cases: in these turtles, isoflurane maintenance provided good management of the anesthesia. The choice between isoflurane and sevoflurane was dictated by the local availability of suitable equipment.

Little research has been directed at pain management in reptiles, and this topic continues to be a source of frustration for veterinarians, given that so little information is available on which to base clinical decisions. Nearly all practitioners believe that reptile patients have the capacity to feel pain, and butorphanol (a mixed agonist-antagonist opioid receptor) and non steroidal anti-inflammatory drugs (NSAIDs) are the most commonly used analgesics for reptiles, even though their pharmacokinetics, effectiveness, doses, dosing intervals, and safety are largely unknown. Nonetheless, little research has been directed toward recognition, assessment, and management of pain in reptiles. As a result, there is a paucity of information on which to base clinical decisions relating to pain management; in addition, no reliable pain score is currently available for correctly evaluating the presumptive analgesic activity of drugs in reptiles. Until further studies are carried out to elucidate pain perception and response in reptiles and amphibians, any disease or process involving pain in other species should also be considered painful in reptiles and amphibians and treated accordingly (Bennett 1998, Bradley 2001). Furthermore, in reptiles, all drugs, including NSAIDs, are used off-label, with posological schedules based on extrapolation from mammalian dosages. However, anatomic and metabolic differences in reptiles and mammals could make extrapolations ineffective or dangerous, resulting in potentially lethal adverse effects. Recent studies have evaluated reptile analgesia (Norton 2005), and the analgesic potential of opioid agonists (Sladky et al. 2009), buprenorphine (Kummarov et al. 2008), and combinations of buprenorphine and hydromorphone (Mans et al. 2012) in red-eared slider turtles *Trachemys scripta*, of morphine and pethidine in Speke's hinged tortoise *Kinixys spekii* (Wambugu et al. 2010), ketoprofen in green iguanas *Iguana iguana* (Tuttle et al. 2006), butorphanol and meloxicam in ball pythons *Python regius* (Olesen et al. 2008), meloxicam in green iguanas *I. iguana* (Divers et al. 2010), and meloxicam in loggerhead sea turtles *Caretta caretta* after single-dose intravenous (Clauss et al. 2007) and intramuscular (Soloperto et al. 2011) administration. However, the results have often been quite contrasting or unconvincing.

With these premises, although aware of the need for pre- and post-operative pain management, the authors chose not to use analgesic drugs on an endangered wild species such as the loggerhead sea turtle.

The resolution to perform further radiography (namely latero-lateral and cranio-caudal) in addition to the classic dorso-ventral, provided a more accurate localization of the hook and positioning of point and barb. In fact, in many circumstances, and especially when the hook is localized in the intracoelomic part

of the esophagus or in the cardia of the stomach, that is to say very close to the bronchi or major pulmonary vessels, prior knowledge of its exact position enables risky movements to be avoided while attempting to remove the hook. The supraplastron approach described by Jaeger et al. (2003) made it possible to reach the caudal part of the esophagus in the cranial coelom without exerting the excessive traction that a cervical approach would require.

The anatomical arrangement and the great mobility of the stomach made it easy to remove the hooks either with a left axillary or with an inguinal approach. In most cases, the choice was dictated by the position of the hook, by any branchlines coming out of the mouth or engaged in the intestine. Hooks in the body or in the fundus of the stomach, often associated with lines coming out of the mouth, were best approached from the axillary region, while hooks lodged in the pyloric tract were best removed using the inguinal approach, which was also useful for extracting lines from the intestine. The inguinal approach was always preferred when seeking to reach the intestine, choosing either the left or the right prefemoral fossa according to the localization of the hook. The choice of approach side for the extraction of long branchlines engaging large tracts of intestine was initially random, while subsequently approaching from the right was always preferred, as this facilitated exteriorization of wider intestinal loops; by contrast, this procedure was more difficult from the contralateral side and the exteriorization of distal jejunum to middle ileum, which more often presented plication, intussusception, or tears as a consequence of stronger tractions exerted by the line, were somewhat arduous.

Although drifting longline fishery is well recognized as a serious threat for sea turtles (Camiñas & De la Serna 1995, Laurent et al. 2001, Lewison et al. 2004, Camiñas et al. 2006), some authors claim that bycatch turtles are able to tolerate severe injuries and, in spite of this, to keep feeding even with one or more hooks lodged in the digestive tract (Tomas et al. 2001, Alegre et al. 2006). Indeed, information on survival rate and entity of injuries in post-hooked turtles is scarce, as in many cases fishermen immediately release bycatch turtles (Orós et al.2004); nonetheless, some authors have estimated that approximately 15 to 50% die from the lesions engendered by fishhooks and lines (Lizana & Bardillo 1997).

Given the substantial number of animals observed, the results of the present study clearly establish that the ingestion of fishhooks and/or above all of long lines almost always causes severe injuries in the digestive tract that, in our study, were the cause of death in 19.8% of cases (25 of 126). In many cases, in fact, even hooks with very short lines caused an acute inflammatory process with ulcerative and fibrinous esophagitis and enteritis, and traumatic perforation of the gastrointestinal wall; similar injuries have been documented by other studies on digestive pathology in some cases of stranded sea turtles (Orós et al. 2004, Valente et al. 2007). On the other hand, long branchlines, with or without hooks, could engage long tracts of intestine, thus leading to traction, plication, and tearing of the intestinal wall. In these circumstances, surgery for the removal of foreign bodies proved to be the only solution.

Radiographic monitoring of spontaneous progression and expulsion of hooks may help avoid surgery, but on the other hand it requires long waiting times, with the possible impairment of the turtle's clinical condition. Therefore, in the authors' opinion, this should never be considered where the presence of the line is evident or suspected, or where the patient is in poor clinical condition on admission. An experimental study in 11 juvenile sea turtles with a hook lodged in the esophagus or stomach revealed that about 50% of them were able to eliminate the hook in 2 yr without distress (Alegre et al. 2006). In the authors' opinion, it is inadvisable to maintain sea turtles in captivity for so long, and considering the reported low percentage (2.7%) of spontaneous expulsion of hooks, together with the high risk of exacerbating conditions during such a wait, it is felt that surgery should be planned in a reasonably short timeframe.

The features, extent, and severity of the injuries caused by lines on the intestinal walls seem to be related to nylon weight. In fact, when thicker branchlines, typical of drifting longlines designed for tunas and swordfish, were found, the intestinal wall presented with important edema and congestion, while necrosis and tears were infrequent. By contrast, thinner lines caused severe plication, strangulation, tears, and encapsulation of the nylon in fibrinous reactive granulomas. These findings are probably attributed to the stronger pressure exerted by tensed thin lines on narrower tracts of the intestinal wall, thus more easily leading to tearing. The extent of enterotomy required varies according to the surgical team's ability to remove tracts of the branchline engaged in long intestinal segments; as a matter of fact, a large number of enterotomies were required when the tightness of a long line caused severe plications of intestinal loops.

Furthermore, the results of the present study showed that extent and severity of injuries are not predictive of prognosis in sea turtles, as they must be related to the clinical condition of the animals at admission. In fact, in many circumstances the turtles recovered fully and were released back to the wild in spite of large tears or resections of long intestinal tracts; by contrast, in other cases, the animals were referred without serious injuries, but the final outcome was fatal. This apparent contradiction may be due to the general conditions of the turtles at the moment of interaction with the drifting longline, or to the elapsed time before rescue. If the bycatch occurs during or at the end of the cold season, when weight loss is quite frequent due to the paucity of food, adverse climatic conditions and impossibility to feed can cause a rapid decline in the general conditions of turtles. In these cases, the ability to fully recover after surgery for removal of foreign bodies is seriously compromised. It remains that in most cases surgery is the only way of saving bycatch sea turtles ensnared by drifting longlines. Thanks to the development of surgical techniques to approach the coelomic cavity, which are both easier to perform and minimally invasive, the removal of hooks and lines is quite rapid, and percentage survival very satisfactory.

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