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Computed tomography findings in stranded loggerhead sea turtles

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Stranded marine turtles often present traumatic injuries related to human activity. Computed tomography (CT) is the reference imaging technique for polytrauma patients. The aim of this report is to describe the CT findings encountered in stranded marine turtles. Total-body CT scans were obtained in seven loggerhead sea turtles (Caretta caretta). Post-processing involved multi-planar reconstruction and volume rendering. All the turtles included in the study had single or multiple lesions of the musculoskeletal system. Six turtles presented bone fractures, while one turtle showed a vertebral abnormality (scoliosis). In five turtles alterations of the lungs were evident. Four turtles had evidence of damage to the central nervous system. No lesions associated with the urinary tract or the liver were identified. In conclusion, lesions of the skeletal, respiratory and nervous systems were frequent and the CT scan was a useful diagnostic tool in traumatised turtles to detect and delineate the extent of the injuries and to monitor the progression of healing.

Keywords - Trauma, computed tomography, diagnostic imaging, reptiles, aquatic animals, turtle.

INTRODUCTION

The loggerhead sea turtle (*Caretta caretta*) is the most common marine turtle species present in the Mediterranean Sea. The species is highly endangered throughout the Mediterranean basin and in Italian territorial waters it is now on the brink of extinction.[1] The IUCN Red List classification on the conservation status of the common sea turtle has changed from "vulnerable" to "endangered"[2] and the estimated number of loggerhead sea turtles in Italy is between 55 and 131 adult specimens.[3] Italy hosts several specialized centres for the rescue, hospitalization and reintroduction of this species into the marine habitat. The improvement of existing conservation plans must be associated with appropriate medical and veterinary intervention plans for the management of these aquatic reptiles.

Although many natural diseases have been described[4-7] in stranded sea turtles or in turtles recovered by fishing boats, these specimens typically present traumatic injuries associated with human activity.[8] In a study on 93 sea turtles recovered in the Canary Islands, 70% had died from causes associated with human activity (accidental collision of turtles with boats, accidental interaction with fishing gear and ingestion of or contact with toxic substances). Specifically, about a quarter of the turtles (24%) died due to collisions with boats.[8] Another study about traumatised sea turtles described complications secondary to trauma that subsequently caused the death of some subjects (yolk embolism).[9]

In such contexts, the use of diagnostic imaging techniques that allow the evaluation of the body organs most frequently involved in trauma would be ideal to provide the appropriate therapy and prognosis.

Multi-slice CT has revolutionized diagnostic imaging in polytrauma patients,[10] in both human[11] and veterinary[12-14] patients, turtles included.[15,16] Only a few studies have

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described the clinical use of CT in the *Caretta caretta* loggerhead turtle, and these are mainly descriptive anatomical studies.[17,18]
Aim of this study is to describe the CT findings observed in stranded sea turtles or in turtles recovered along the Italian coasts.

CT has revolutionized diagnostic imaging in polytrauma patients.

MATERIALS AND METHODS

Animals

The current study included specimens of loggerhead sea turtles (*Caretta caretta*), rescued by the Recovery Centre of the non-profit organization Cetacea Foundation Onlus (Riccione, RN - Italy), which underwent whole-body CT scans in the Modena Sud Veterinary Clinic (Spilamberto, MO) for diagnostic purposes. The physical examination included: weighing, measurement of the curved carapace length, cloacal temperature, heart and respiratory rate, sexing when phenotypically evident, assessment of body condition and of any surface injuries. In cases with evident or suspected head injury a neurological examination was performed. Radiography and blood chemistry tests were performed based on the clinical indications.

Anaesthesia protocols

A jugular intravenous catheter was placed in all subjects and a fasting time of at least 12 hours prior to anaesthesia was complied with. Two anaesthesia protocols were used. In turtles requiring an invasive clinical procedures following CT (e.g., surgical curettage, fracture reduction, etc.) the protocol consisted in the administration of midazolam (Midazolam - Hameln, Hameln Pharmaceuticals GmbH, Hameln, Germany) 1.5 mg/kg and butorphanol (Dolorex, Intervet Int BV, Boxmeer, the Netherlands) 0.5 mg/kg combined in the same syringe and injected into the deltoid muscle.[19] After 15 minutes, medetomidine (Domitor, Orion Corporation, Espoo, Finland) 0.18 mg/kg and ketamine (Imalgene 1000, Merial SpA, Milan, Italy) 8 mg/kg, mixed in the same syringe, were injected into the contralateral deltoid muscle. At the end of the procedure, atipamezole (Antisedan, Orion Corporation, Espoo, Finland) 1.8 mg/kg was administered in the right deltoid muscle. The second protocol, for turtles undergoing only the CT study, consisted in a light sedation with 5 mg/kg of propofol IV (Rapinovet, Intervet, Millsboro, DE, USA), in order to ensure immobility during image acquisition.[20]

Image acquisition and assessment

For the acquisition of the tomographic images, using a multi-slice CT (BrightSpeed Edge Advantage, GE, Milwaukee, WI), the turtles were positioned in ventral recumbency. Whole-body spiral CT scans with 1.25 mm slice reconstructions were performed on each specimen. The scans were examined by an ECVDI Radiology Diplomate using multiplanar and volume randering reconstructions.

RESULTS

Population characteristics

The study included seven loggerhead sea turtles (*Caretta caretta*), weight range between 8.2 and 71 kg (median ± standard deviation: 13 ± 22.3 kg). All specimens were rescued in the Adriatic Sea by the Recovery Centre of the Cetacea Foundation Onlus (Riccione, RN - Italy). Five subjects were recovered by fishing boats, four off the coast of Ancona (AN) and one off the coast of Marina di Ravenna (RA). Two turtles were stranded, respectively, in Comacchio (FE) and Cesenatico (FC). The turtles included in the study presented various diseases and several subjects were in critical conditions. An x-ray of the skull was performed in two subjects, revealing comminuted fractures of the jaw and of the jugal bones.

CT findings of the musculoskeletal system

The CT examination identified musculoskeletal lesions in all subjects. Bone fractures were present in six specimens (Nos. 1, 2, 3, 5, 6, 7). Five subjects (Nos. 1, 2, 3, 5, 6) presented depressed skull fractures (Figure 1); in four subjects (Nos. 1, 2, 3, 5) fractures involved the frontal bones, in case No. 2 also the parietal bones and in cases Nos. 1 and 5 the fractures were associated with encephalic compression.
Case No. 6 presented fractures of the parietal and postorbital bones with encephalic exposure.
Subject No. 4 presented asymmetry of the carapace with an extensive compression of the left side, with the spine deviated in contralateral direction to the cervical-thoracic compression (i.e., vertebral scoliosis).
Subject No. 7 presented comminuted fractures of the plastron and carapace associated with subcutaneous, coelomic and muscular emphysema.

CT findings of the respiratory tract

Five specimens (Nos. 2, 3, 4, 5, 6, 7) presented evident pulmonary lesions (Figure 2). No. 3 had the right

CT examination identified musculoskeletal disorders in all subjects.

cranial lung lobe resected by a deep full-thickness tear. No. 4 presented the left lung with reduced volume, loss of the edicular architecture and fibrosis; the right lung exhibited bronchial wall thickening, increased lung density and the presence of emphysema (dilatation of the lung fields with destruction of the alveolar septa, without significant fibrosis).

No. 5 presented an area of interstitial infiltration in the medial portion of the left lung and a focal area of pulmonary infiltrate in the caudal portion of the right lung, partially mineralized. No. 6 presented an increased interstitial density of the left lung, with focal pleural thickening, and focal infiltration in the most caudal portion of the right lung, consistent with a bilateral chronic lung disease. No. 7 presented an increased interstitial density, pleural thickening, the presence of various dishomogeneous nodules in both lungs and focal infiltrations in the more caudal portion of the right lung; findings consistent with chronic granulomatous bilateral lung disease.

Five specimens presented evident pulmonary lesions.

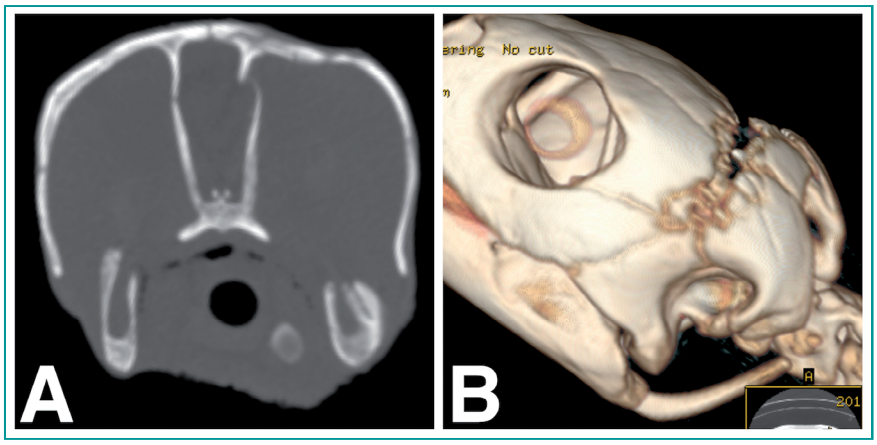

Figure 1 - Transverse CT image (A) and volume rendering (B) of skull fractures in a *Caretta caretta* specimen. Notice the presence of the scleral bone, visibile as a bony ring around the cornea.

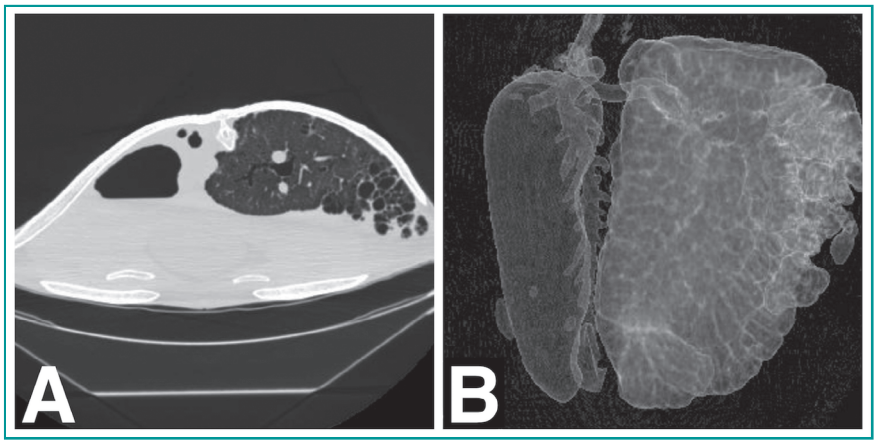

Figure 2 - Transverse CT image (A) and volume rendering (B) of lung lesions in a *Caretta caretta* specimen. The subject presented an evident floating problem.

CT findings of the central nervous system

Lesions of the central nervous system were found in 4 subjects (Nos. 1, 3, 5, 6). Subjects Nos. 1 and 5 presented an evident encephalic compression associated with a displaced fracture of the frontal bone. Clinically, both turtles were incapable of swimming and feeding themselves autonomously.

Subject No. 1 presented a spastic contraction of the hind limbs in extension and a delay in the water righting reflex. In subject No. 5 the righting reflex was absent.

Subject No. 3 presented a subtotal laceration of the spinal cord at the level of the first carapacial vertebra (Figure 3). Clinically, despite using only the front flippers the subject was able to swim, dive and accept offered food without difficulty.

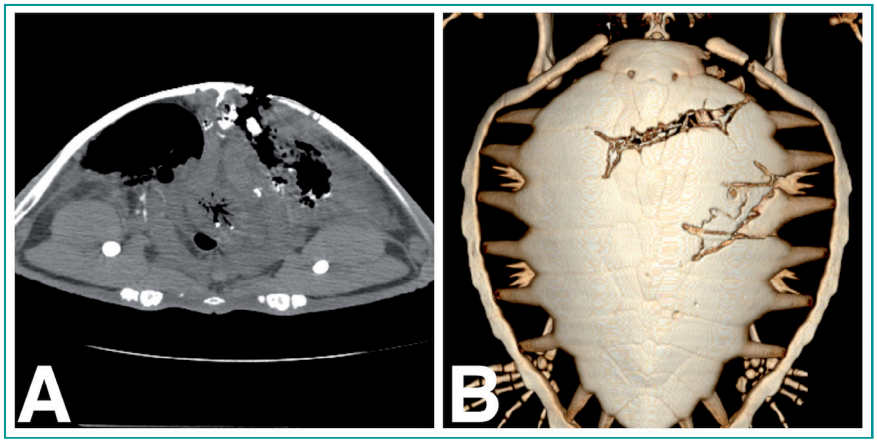

Figure 3 - Transverse CT image (A) and volume rendering (B) of a fracture of the first carapacial vertebra and of a lung lesion in a *Caretta caretta* specimen. The subject was paraparetic but capable of diving and feeding.

As a result of multiple fractures of parietal and postorbital bones in subject No. 6 the fractures extended to the skull, with partial exposure of the encephalon.

Clinically, the specimen was unable to dive and presented a floating defect, with sinking of the left part of the body; it was also impossible for the turtle to fully open its mouth and grasp offered food.

CT findings of other body organs

Four subjects (Nos. 1, 3, 5, 6) had an empty gastrointestinal tract, subject No. 7 presented sandy material in the oral and oesophageal cavity, subject No. 2 had some intestinal food material and subject No. 4 presented residues of shells in the stomach and intestines.

Three specimens were females: the ovaries were identified in subjects Nos. 1 and 4, while the eggs in No. 2. Specimen No. 5 was a suspected male and in the remaining specimens, Nos. 3, 6 and 7, the sex was unidentifiable.

In all the studied specimens CT scans did not show any abnormality of the urinary tract or of the liver.

Mortality and follow-up

In subjects Nos. 1 and 2 a whole-body CT study was repeated at a distance of two months, revealing the presence of fibrotic and osseous calluses in various fracture sites. Turtles Nos. 1 and 2 were released after application of satellite radio transmitters. Subject No. 4 was released without a transmitter after a period of rehabilitation in a confined marine area.

Turtles Nos. 3, 5 and 6 remained hospitalized as they were considered unfit for reintroduction into the marine habitat. Subject No. 7 died on the ninth day of hospitalization.

DISCUSSION

CT examination is considered the elective imaging technique in the assessment of trauma patients.[11-14] In this series of seven specimens of *Caretta caretta*, CT scans proved to be an accurate tool in estimating the extent of traumatic injuries, particularly of skull and spinal fractures and of lung lesions; CT scans proved useful also in revealing compression of nerve structures. In the two cases in which long-term follow-up examinations were performed, CT provided useful information on the state of recovery of the subjects.

In human polytrauma patients a "selective CT" approach is used, in accordance with the guidelines developed by the Advanced Trauma Life Support committee (ATLS), consisting in the physical examination, conventional x-rays (thorax and pelvis), FAST ultrasonography (Focused Abdominal Sonography for Trauma) followed by a CT of the traumatised area.[21,22] In sea turtles a similar approach is not applicable, as ultrasonography is limited to the assessment of the coelomic cavity[23] and cannot be used in other body parts in view of the presence of the plastron and carapace. Given the type of lesions found in the present study (skeletal, lung and central nervous system lesions), an ideal approach in polytrauma marine turtles should include a whole-body CT.

The skull of the *Caretta caretta* is composed of the prefrontal, frontal, parietal, postorbital, supraoccipital, squamosal, quadratojugal, jugal, and maxillary bones.[16,24] In the present series of cases cranial injuries were frequent (5/7 cases) and involved the frontal, parietal and postorbital bones. In a previous study on stranded marine turtles in the Canary Islands skull fractures were not frequent, with only two cases reported.[8] In such study, only 23% of the specimens presented fractures, and they all involved the carapace, plastron and limbs. This considerable difference could be secondary to the non-use of advanced diagnostic techniques, such as CT, in the Canary Islands study, or to the different environment, with sea turtles in the Adriatic Sea being more vulnerable to collisions with boats.

In polytrauma sea turtles CT scans allows a rapid assessment of the animal and a detailed characterization of the most frequently observed lesions.

In four specimens, no material was present in the digestive tract. Considering that the transit time of ingesta in loggerhead sea turtles is between 9 to 13 days,[25] it is possible that at the time of the trauma the turtles had non been eating for a few days. Inappetence could have been consequent to the presence of other systemic disorders and an association is therefore plausible between the presence of a systemic disease and a traumatic injury. Additional studies are necessary to investigate such hypothesis.

In accordance with a previous study,[8] pulmonary lesions were frequently found in stranded turtles. In turtle No. 3, lung lesions were probably of traumatic nature. Lung lesions are often associated with carapace trauma, in view of their dorsal position, in contact with the carapace and the spinal column.[18] In the remaining six rescued turtles included in the study the cause of the lung lesions could not be determined on the basis of CT findings. According to some authors, the marked prevalence of lung lesions in rescued sea turtles is indicative of a predisposition of these animals for such type of injury,[8] possibly associated with the entry of bacteria within the respiratory tract following aspiration of marine water.[8,26]

In conclusion, in polytrauma marine turtles CT scans allows a rapid assessment of the specimen and a detailed characterization of the most frequently encountered lesions, i.e. at skeletal and pulmonary level.

KEY POINTS

- Stranded marine turtles often present traumatic injuries related to human activity.
- Computed tomography (CT) is an accurate and reliable imaging technique for human and veterinary polytrauma patients.
- Musculoskeletal disorders were present in all the included subjects (7/7).
- Bone fractures were identified in six subjects, while the seventh subject presented vertebral scoliosis.
- Five subjects presented respiratory tract alterations.
- CT scans proved usefulness in assessing skeletal, pulmonary and central nervous system lesions in polytrauma sea turtles.

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