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Synopsis on the Most Common Pathologies of Dolphins

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ABSTRACT

Dolphins are one of the most iconic species of the marine world. With their playful nature and high intelligence, dolphins have enthralled the hearts of people of all ages from all over the world. The worldwide distribution of dolphins through the diverse global aquatic environments has gifted them with global popularity compared to other aquatic animals in direct contact with the human communities. In the past few decades, deaths, injuries, toxicities, genetic disorders and overfishing were continuously increasing due to faulty anthropogenic activities in th marine environment. The increasing global threats to dolphins' populations have remarkably enhanced the public awareness about these threats and triggered scientific communities to configure reliable/effective solutions. Combating trans-species infectious diseases and development of reliable, safe and cheaper diagnostic as well as therapeutic tools for tissue alterations were the infrastructure of dolphins' veterinary research through the past few decades. However, the veterinary library is suffering from remarkable scarcity of comprehensive literatures about diseases/disorders affecting different body systems of marine mammals. Thus, we present the current review in trial to shed the light on the most common affections of dolphins as a model of the most critically impacted marine mammals.

Key words: Bottlenose dolphin, dolphins, franciscana dolphin, lobomycosis, stripped dolphin

INTRODUCTION

Dolphins are cetacean mammals closely related to whales and porpoises. There are almost forty species of dolphin in 17 genera. Most of these species live in shallow areas of tropical and temperate oceans throughout the world (Fig. 1). Five species live in the world's rivers. Dolphins can live a relatively longer life, when compared to other marine and terrestrial animals. A dolphin's age can extend to 60 years in certain species (*Stripped dolphin*) comparable to a human living to be about 100 years (Tyack, 1986). A dolphins species also plays a big role in determining, how long a dolphin will live. For example the Amazon river dolphin (a freshwater dolphin) has a life expectancy of only 15-20 years, while the *Stripped dolphin* may live to be 50-60 years (Mann, 2000). While, it is unclear whether or not their habitat is solely responsible for their lifespan, we can assume that their lifespan may be partially based on their species. The relatively long life of a dolphin in a wild aquatic environment that contains exotic dangerous predators, such as sharks, killers whales and orcas can possibly amplify the incidences of deadly bodily injuries, interspecies infectious diseases transmissions and ultimately mass mortalities (Ross, 2002; Van Bressem *et al*., 2006).

Human impact is a detrimental factor in the dolphins lifespan. Deaths, injuries, toxicities, genetic disorders and overfishing are continuously increasing due to anthropogenic activities.

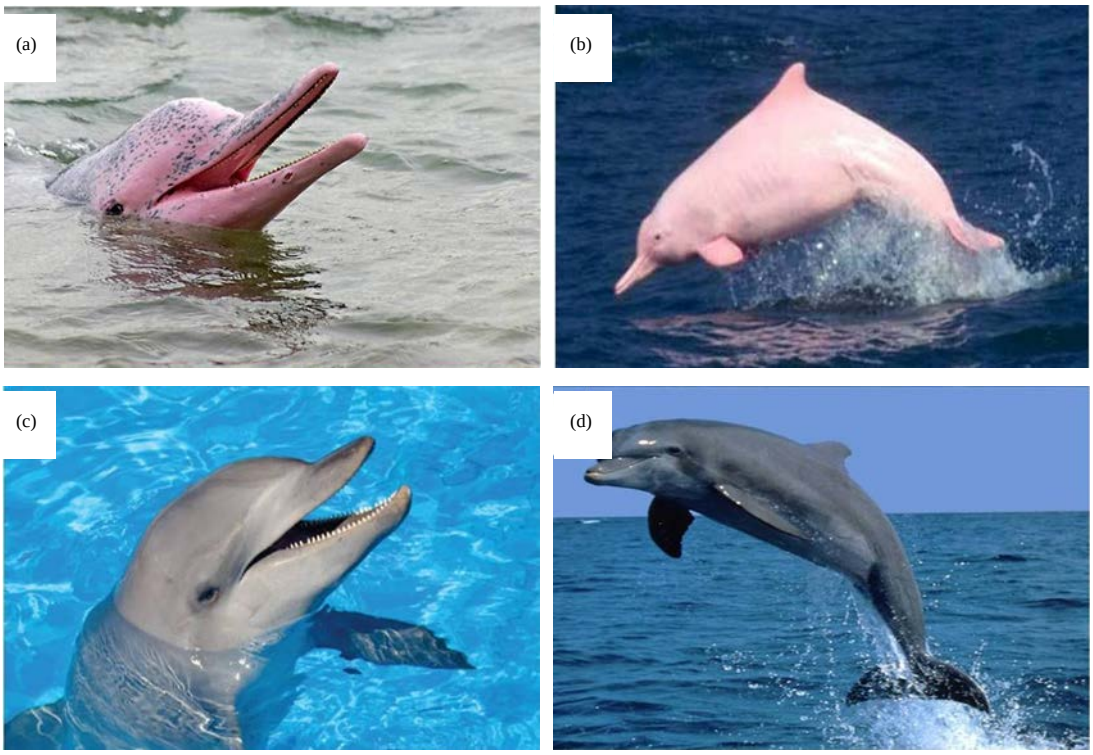

Fig. 1(a-d): (a and b) Amazon pink dolphin, (c and d) Bottlenose dolphin (Pictures are courtesy of Defenders.org)

Dolphins, particularly coastal animals, are affected by heavy boat traffic, habitat destruction and pollution. Industrial and agricultural pollutants in coastal habitats have resulted in high levels of toxins in the water and high concentrations of toxins in the dolphin tissues. In the past, bottlenose dolphins have been taken directly for meat, leather, oil and meal (for fertilizer and animal feed). Hunting still occurs in various parts of the world including Peru, Sri Lanka, Taiwan and Japan. In the course of fishing operations, gear and nets can accidentally entangle and injure or drown dolphins. Dolphins that are injured or killed and discarded in the course of fishing operations are called bycatch. Experts have concluded that it's likely hundreds of thousands of marine mammals are killed as bycatch each year. The incidental capture of whales and dolphins in fishing gear is one of the most significant threats to some bottlenose dolphin populations. In the United States, when data indicate that the bycatch of a species exceeds its sustainable removal threshold, experts must develop and implement a plan for reducing bycatch. As a result, whales has declined since, 1995. In some areas, prey populations become overfished, leading to depleted populations of dolphins. In the Mediterranean and Black Seas, for example, prey depletion by commercial fisheries caused significant drops in populations of bottlenose dolphins. Feeding, swimming with animals, or intruding on wild environments also can have a negative influence on many other normal marine mammal behaviors. People are disturbing dolphin resting areas. Scientists believe that the long-term effects of such activities may include the disruption of normal resting patterns, mother-calf nursing and bonding behaviors and social interactions between animals.

Significant advances in aquatic veterinary diagnostic and surgical approaches have been developed through the past several decades. Many of these advances, however, have not reached the field of marine mammal medicine. A number of limitations exist: risks of anesthesia, anatomical challenges, difficulties with wound closure, environmental constraints, equipment limitations and perceived risks. Despite of these limitations, surgical treatments have been successfully, utilized in marine mammals. Thus, the aim of this work was to address and review different body disorders/alterations in an effort to determine challenges that must be bridged in order to adopt a more feasible surgery as diagnostic and/or corrective options for affected dolphins.

Congenital anomalies: The first case of a white franciscana dolphin has recently been reported by Cremer *et al*. (2014). They have sighted an albino franciscana dolphin with an anomalously coloration in Babitonga Bay, southern Brazil. The calf was totally white. Besides the potential mother and newborn, the group also had the presence of another adult, who always was swimming behind the pair. Both adults had grayish brown back. Between first and last sighting of the white calf (113 days) the color has not changed.

Liste *et al*. (2006) have recorded a case of hydrocephalus in newly born bottlenosed dolphin (*Tursiops truncatus*). Double faced monster among bottlenose dolphins (*Tursiops truncatus*) were found in the Mediterranean sea (Dabin *et al*., 2004). Skeletal pathology descriptions have shown changes to axial skeletons because of injury, trauma, or disease. There are many reports of cetaceans with deformed and twisted bodies. Congenital scoliosis of a bottlenose dolphin (*Tursiops truncatus*) was recorded. In spite of severe deformities, the dolphin lived 18 years and raised two calves (DeLynn *et al*., 2011).

Van Bressem *et al*. (2006) have observed miscellaneous lesions of the head, skull, teeth, trunk, appendages, skin and genital tract in 120 of 930 long-beaked common dolphins *Delphinus capensis*. Prevalence of malformations and traumas of crania were 2.9 and 1.9%, respectively. Lytic cranial lesions were present in 31.1% of dolphins. Skull damage diagnostic for *Crassicauda* sp. infestation was encountered in 26.5% of dolphins and did not differ among sex and age classes. Adult dolphins showed a high prevalence of worn and broken teeth (35%) as well as damaged alveoli (20%). Prevalence of 'paired teeth', a congenital condition, was 9.4%. Lesions of the head, body and appendages included traumas, deformations (e.g. scoliokyphosis and brachygnathia) and chronic mastitis. Ovarian cysts, vesicular lesions of the penis and chronic orchitis were also observed.

Examples of different congenital anomalies of dolphins are presented in Fig. 2.

Skin affections: Although, generally considered non-fatal, skin disease may be indicative of animal health or exposure to anthropogenic or environmental threats. Skin affections of dolphins are very common due to their immensely energetic mobility through their aquatic environments exposing them to predators, hunters, physical accidents, trans-species horizontal infections of skin (Fig. 3, 4). Further, their ordinary/long term existence at marine environments with close vicinity to anthropogenic activities might predispose them to various types of skin affections. Luksenburg (2014) has concluded that injuries in marine mammals can be used to examine interactions with human activities and identify potential threats to the survival of populations. He has defined eleven injury categories and linked them to either human-related activities or natural causes. In total, 18.7% of all individuals had at least one injury. Almost half (41.7%) of the injuries could be attributed to human interactions of which fishing gear was the most common cause

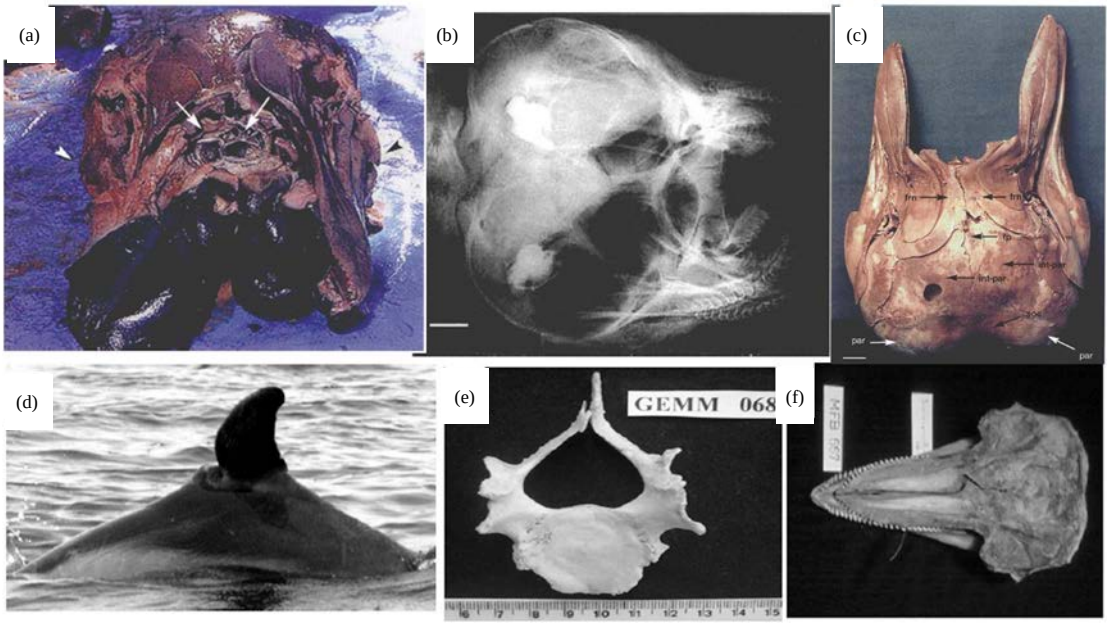

Fig. 2(a-f): Different congenital anomalies of dolphins, (a) Frontal view of the head of the dolphin during dissection showing the locations of two blow holes (arrows) and two eyes (arrow heads), (b) Radiograph of the head showing the two complete beaks and the teeth, as well as the single, abnormally wide brain case with two auditory bullae (denser areas). Bar = 2 cm, (c) Dorsal view of the skull showing that the facial bones are duplicated. frn Frontal, fused parietals, fp Fused parietals, int-par Interparietals, par Parietals, soc Supraoccipital. Bar = 2 cm, (d) Deformation of dorsal fin in an inshore *Tursiops truncatus* from the Bay of Paracas (Peru)., (e) Congenital malformations in the seventh cervical vertebra of a *Sotalia guianensis* from Northern RJ (Brazil) and (f) Complete skull malformation in an adult *Lagenorhynchus obscurus* (Peru) a, b and c were adopted from Dabin *et al*. (2004), while d, e and f were adopted from Van Bressem *et al*. (2007)

(53.3%) followed by propeller hits (13.3%). Shark-inflicted bite wounds were observed in Atlantic spotted dolphin and bottlenose dolphin. Hart *et al*. (2012) have reported some skin lesions on common bottlenose dolphins (*Tursiops truncatus*) from three sites in the Northwest Atlantic.

Nodular/localized skin lesions have frequently reported among different dolphins worldwide. Lesions were attributed to diverse non infectious and infectious causes. Soto *et al*. (2010) have described a rare case of multifocal granulomatous nutritional panniculitis associated with vitamin E deficiency in Mediterranean striped dolphins (*Stenella coeruleoalba*). Bonar and Wagner (2003) have reported a dermatologic syndrome characterized by the occurrence of slow-growing, nodular, s.c. abscesses associated with *Streptococcus iniae* in an Amazon River dolphin (Inia geoffrensis). Vigorous surgical management of the abscesses, including lancing, debridement and irrigation, combined with antimicrobial therapy and improvement of the animal's diet and environmental water quality led to gradual recovery.

Fig. 3: Ulcerative skin lesions of different origins in bottlenose dolphins (Pictures are courtesy of oceanwildthings.com)

Lobomycosis (Fig. 4), a disease caused by the uncultivable dimorphic onygenale fungi *Lacazia loboi*, remains to date as an enigmatic illness, both due to the impossibility of its etiological agent to be cultured and grown in vitro, as well as because of its unresponsiveness to specific antifungal treatments. Paniz-Mondolfi *et al*. (2012) have indicated that it causes cutaneous and subcutaneous localized and widespread infections in humans and dolphins. Lobomycosis Like Disease (LLD) and Nodular Skin Disease (NSD) were also reported by Van Bressem *et al*. (2009) in a community of Guiana dolphins (*Sotalia guianensis*). Lobomycosis is referred to as a zoonotic disease because it affects only specific delphinidae and humans; however, the evidence that it can be transferred directly to humans from dolphins is weak. Dolphins have also been postulated to be responsible for an apparent geographic expansion of the disease in humans (Reif *et al*., 2013). Dolphin lobomycosis-like lesions might have been be caused by a different fungus clustered inside the order Onygenales. A successful treatment protocol based on topic and systemic terbinafine is used (Esperon *et al*., 2012).

Van Bressem *et al*. (2014) have reported the presence of cutaneous nodules (Fig. 4) in vulnerable populations of Irrawaddy dolphins *Orcaella brevirostris* from Malaysia, India and Bangladesh. They appeared as circumscribed elevations of the skin and varied in size from 2 to >30 mm, were sparse or numerous and occurred on all visible body areas. The lesions remained stable or progressed over months but did not regress. Histologically, the lesions consisted of thick collagen bundles covered by a moderately hyperplasic epithelium and were diagnosed as fibropapillomas. Dolphins are well known definitive hosts of parasitic nematodes of the genus *Anisakis* (Nematoda: Anisakidae). In the stomachs of marine mammals, the nematodes

Fig. 4(a-d): Proliferative lobomycosis-like disease on the (a) Beak and (b) Dorsal fin, of a bottlenose dolphin (*Tursiops truncatus*) stranded on Margarita Island, Venezuela (Courtesy of Bermudez *et al*., 2009), (c) Progressive keloid like lesions of lobomycosis on head, beak (c) and Tail fin (d) of a bottlenose dolphin (*Tursiops truncatus*) (Courtsey of Paniz-Mondolfi *et al*., 2012)

develop from third-stage larvae to adults causing mucosal ulceration in the first (or fore-) stomach. Van Beurden *et al*. (2015) have found remarkable gastric A. simplex infection, as well as chronic granulomatous and ulcerative dermatitis with intra-lesional nematodes were found in a bottlenose dolphin *Tursiops truncatus*. Anisakid nematodes are also a health hazard for humans, causing gastrointestinal infections or allergic reactions following the consumption of infected fish.

Ueda *et al*. (2013) have reported that a female bottlenose dolphin (*Tursiops truncatus*) in captivity developed necrosis of the tail flukes. Although, the diseased site healed after surgical resection, the loss of approximately 75% of the tail greatly affected her swimming performance. To restore swimming ability, artificial tail flukes as a prosthetic swimming aid and physical therapy were successfully applied.

Assessment of injuries in marine mammals may be required to help authorities determine whether human activity was involved (Byard *et al*., 2012).

Neoplasms: Due to obtaining inadequate samples from wild populations of marine mammals, expansion of the literature, in particular, that associated with neoplasia, has been slow. However, cancer in marine mammals has always been of interest to veterinary pathologists because of the common environmental exposures that can initiate carcinogenesis in animals and people. These animals may be used as sentinels for environmental problems, particularly in regard to toxin exposure. Neoplasms in these species may be related to infectious and/or carcinogenic chemical exposure. Neoplasia, especially epithelial tumors has been reported more often in dolphins than in any other marine mammal species. The organ systems reported to be most commonly affected in dolphins include skin, lymphatic system, tongue, lung and kidney.

Seminoma with metastasis, Sertoli cell tumor and pheochromocytoma were diagnosed in a spotted dolphin (*Stenella frontalis*) and an Atlantic bottlenose dolphin (*Tursiops truncatus*) (Estep *et al*., 2005).

A large cell immunoblastic lymphoma in a bottlenose dolphin found stranded alive was reported by Jaber *et al*. (2005). Diffuse infiltration of round neoplastic cells was observed in the splenic cords and sinuses and in hepatic sinusoids, resulting in moderate organ enlargement. The tumour cells showed scant, lightly eosinophilic or basophilic cytoplasm, distinct cell boundaries and hyperchromatic nuclei, each with one or more nucleoli. Mitoses were common.

Diaz-Delgado *et al*. (2012a) have presented a mixed testicular neoplasia in a short beaked common dolphin *Delphinus delphis* involving a Sertoli cell tumor, an interstitial (Leydig) cell tumor and a seminoma.

In marine mammals, the incidence and prevalence of Papilloma Virus (PV) infection, transmission pathways and persistence of infection are largely unknown. Papilloma virus infection in bottlenose dolphins is common, that the main route of PV transmission among them may be horizontal and that orogenital neoplasia may develop in early life stages of certain free-ranging bottlenose dolphins (Rehtanz *et al*., 2010). Rehtanz *et al*. (2012) have declared that eight species-specific viruses, seven papilloma viruses (PVs) and two herpes viruses (HVs) have separately been shown to be associated with genital tumors in Atlantic bottlenose dolphins (*Tursiops truncatus*, Tt). Renner *et al*. (1999) have reported a sublingual squamous cell carcinoma in a 22-year-old captive-born Atlantic bottlenose dolphin (*Tursiops truncatus*). The lesion was excised completely and has not recurred.

On 2002, an endometrial adenocarcinoma with areas of squamous differentiation and generalized metastasis was observed in a bottlenose dolphin Tursiops truncatus. This neoplasm likely compromised reproduction for several years. In addition, the dolphin presented tattoo-like skin lesions and its digestive tract was infested by Anisakis simplex, *Pseudoterranova* sp., *Braunina cordiformis* and *Corynosoma australe* (Sanchez *et al*., 2002).

Ewing and Mignucci-Giannoni (2003) have reported a poorly differentiated pulmonary squamous cell carcinoma with lymph node and renal metastasis in bottlenose dolphin

(*Tursiops truncatus*). The left-lung and right-lung pleura had multiple white, firm-to-hard nodules with coagulative necrosis. Histologically, the neoplasms were characterized by multiple well-circumscribed, nonencapsulated expansile masses consisting mostly of polygonal cells with fewer circumferential flattened basaloid cells that compressed alveoli, bronchioles and bronchi. Multiple white, firm-to-hard nodules with coagulative necrosis were recorded.

Miclard *et al*. (2006) recorded a microcystic meningioma in a wild common dolphin. At necropsy, an intracranial grey- to tan-colored mass (7×5×4 cm) was found at the right cerebellopontine angle. Microscopically, the tumor was composed of small lobules of polygonal to elongated neoplastic cells with multifocal areas of stellate and vacuolated cells.

Amazingly, Arbelo *et al*. (2014) have recorded a nodular neoplastic growth in the Central Nervous System (CNS) at the level of the thalamus in an adult female short-beaked common dolphin (*Delphinus delphis*). Microscopical examination revealed T-cell lymphoma.

Interestingly, vascular tumors and disorders, like angiomatosis, are rarely described in cetacean species. However, a retrospective histological study was carried out by Diaz-Delgado *et al*. (2012b) on lung samples from 35 common dolphins (*Delphinus delphis*) stranded in the Canary Islands coasts looking for morphological vascular changes and likely related causes. About 71% of common dolphins showed focal or multifocal angiomatosis-like lesions. A high association between this type of vascular proliferation and parasitic infestation was observed. In addition, a single pulmonary cavernous hemangioma was also presented.

Most recently, Diaz-Delgado *et al*. (2015) have reported a primary uterine T-cell lymphoma in an adult female Atlantic spotted dolphin (Stenella frontalis) with multiple metastases in ovaries, mesosalpinx and urinary bladder. Herpesvirus and morbillivirus PCR were negative.

Rotstein *et al*. (2007) have recorded a gastric leiomyoma in a free-living Atlantic bottlenosed dolphin (*Tursiops truncatus*). The pyloric mass was composed of plump spindyloid cells forming interlacing bundles. Cells had abundant eosinophilic cytoplasm and small, elongated nuclei, with minimal anisocytosis and anisokaryosis. Mitoses were not observed. Immunohistochemical stains revealed leiomyoma.

Demonstration of clinical signs and further health implications associated with neoplasms is extremely challenging when dealing with non accessible wildlife species, such as dolphins. However, metastatic potential for these neoplastic conditions should be considered.

Musculoskeletal affections: In a biophysical study to assess the effect of ankle muscle strength and flexibility on dolphin kick performance in competitive swimmers. Willems *et al*. (2014) have concluded that muscle strength of dorsal flexors and internal rotators is positively correlated with the velocity of a swimmer dolphin. Ultimately, the inferred that dolphin kick velocity might be enhanced by ankle muscle strength exercises and that subjects with a restricted ankle flexibility might profit from a flexibility program.

Some zoonotic human derived' infectious agents are known to have very deleterious health effects on dolphins. *Brucella*, *Brevibacterium*, *Streptococcus*, *Staphylococcus*, *Mycobacterium*, Influenza virus, Papillomavirus, Poxvirus and Morbillivirus are some of numerous infectious agents presenting a critical risk to dolphins as well as their cohabitating humans. Goertz *et al*. (2011) have reported *Brucella* sp. vertebral osteomyelitis with inter-current fatal Staphylococcus aureus toxigenic enteritis in a bottlenose dolphin (*Tursiops truncatus*). Gross necropsy findings included a fistulous tract leading to locally extensive osteomyelitis of a coccygeal vertebra with sequestra and osteophytes from which a *Brucella* species was isolated. Davison *et al*. (2013) have described

Brucella ceti infection specific to the central nervous system in two species of cetacean: striped dolphins (*Stenella coeruleoalba*) in Europe and Costa Rica and an Atlantic white-sided dolphin (*Lagenorhynchus acutus*) in the UK. In their report they recorded the first case of *B. ceti*-associated meningitis and arthritis in a third species, the short-beaked common dolphin (*Delphinus delphis*). Investigating osteomyelitis in dolphins is remarkably difficult. To find macroscopically palpable bone marrow cavities in dolphins is difficult because of their extremely retrogressive limbs and pelvis and because they do not contain abundant modular cavities (as in terrestrial mammals) that can serve as sites for bone marrow biopsies (Itou *et al*., 2010). However, Itou *et al*. (2010) have recommended the implementation of paracentesis at the humerus using a biopsy needle for collection of bone marrow samples from dolphins for further pathological investigations.

In captivity, most of the musculoskeletal disorders of dolphins are traumatic in origin. If there is a long fall or obstruction as exposed pipes, uneven enclosure's walls, traumatic injuries (fractures, hematomas and deep wounds) may develop. Also, fighting between dolphins may cause bone and muscle injuries. Thus, trainers should remove the problematic dolphin from the arena if a conflict on social dominance has developed.

In the wild, scoliosis, lordosis, lumpy dorsal masses, fused monsters and many other skeletal deformities such as vertebral fractures and joints dislocations have been reported. The majority of severe skeletal disorders are attributed to vessels collision, hunting, infectious diseases and environmental pollution (Martinez and Stockin, 2013).

Oblique fractures of Spinous processes and the neural processes on six lumbar vertebrae (L17-L22) and eight caudal (Cd1-Cd7, Cd13; Fig. 4) vertebrae were reported (Martinez and Stockin, 2013).

Abdominal wall affections: Three successive Umbilical Cord Accidents (UCAs) were diagnosed in the same female bottlenose dolphin Tursiops truncatus during consecutive gestations (Garcia-Parraga *et al*., 2014). Coiling of the UC around the peduncle of the foetus was seen by ultrasound. All 3 foetuses were male, died in utero and spontaneously aborted during the last third of gestation.

A routine pregnancy ultrasound examination of a 30-year-old, multiparous, common bottlenose dolphin, Tursiops truncatus, detected an approximately 16-wk (gestational age) fetus with an omphalocele, an abdominal wall defect at the base of the umbilical cord (Smith *et al*., 2013a).

Respiratory system affections: Normally, Dolphins and porpoises had less stiff, more compliant spiraling tracheal rings while beaked whales had very stiff, less compliant spiraling rings (Moore *et al*., 2014). Lung diseases are common among wild and captive populations of dolphins. Abnormal sonographic findings, such as evidence of alveolar-interstitial syndrome, pleural effusion, pulmonary masses and pulmonary consolidation were reported in bottlenose dolphins *Tursiops truncates* (Smith *et al*., 2012). Although, thoracic ultrasound is a valuable diagnostic tool for detecting pleural and pulmonary diseases in dolphins, further diagnostics as ultrasound-guided thoracocentesis, fine needle aspirates and lung biopsies, as well as radiographs and Computed Tomography (CT) exams are essential to obtain definitive diagnoses (Smith *et al*., 2012).

Aspiration of foreign bodies, fishes and body fluids are common causes of tracheal/lung diseases in dolphins. Levy *et al*. (2009) have observed an unusual snaring of the larynx in an adult, female common bottlenose dolphin (*Tursiops truncatus*). Post mortem examination revealed nylon filaments wrapped around the larynx and extending down into the forestomach, where a large mass of netting was found.

One of the causes of neonatal mortalities in captive breeding dolphins is the Meconium Aspiration Syndrome (MAS). Tanaka *et al*. (2014) has reported a case of MAS in a male neonate of bottlenose dolphin (*Tursiops truncates*) who died immediately after birth. At necropsy, a true knot was found in the umbilical cord. The lungs showed diffuse intra-alveolar edema, hyperemic congestion and atelectasis due to meconium aspiration with mild inflammatory cell infiltration.

Upper respiratory tract mycoses is frequently reported problem in dolphins from relatively, polluted environments. Respiratory mycoses due to *Aspergillus fumigates* infection in bottlenose dolphins was presented by segmental to circumferential fibrosing tracheitis that decreased luminal diameter with atypical recurrent upper respiratory signs (Delaney *et al*., 2013). Histologically, tracheal cartilage, submucosa and mucosa were distorted and replaced by extensive fibrosis and pyogranulomatous inflammation centered on fungal hyphae.

Pneumonia with pulmonary abscesses have frequently been reported in bottlenose dolphin (*Tursiops truncatus*). Diagnostic imaging, including radiographs and computed tomography of affected lung as well as other microbiological examinations have revealed that Brucellosis (Cassle *et al*., 2013), Mycobacterium abscesses infection (Clayton *et al*., 2012), Morbillivirus infection are all incriminated as possible causes of pneumonia in bottlenose dolphins. It is worthy to mention that personnel who interact with marine animals should use caution to avoid contracting infection of such zoonotic diseases.

Urinary system affections: Argade *et al*. (2013) have identified several cases of nephrolithiasis in managed populations of bottlenose dolphins (*Tursiops truncatus*); most of these nephroliths are composed of 100% Ammonium Acid Urate (AAU). Several therapies are being investigated to treat and prevent nephrolithiasis in dolphins. Adjustment of urinary pH alone does not appear to be a useful way to treat AAU stones in bottlenose dolphins. Better understanding of the pathophysiology of AAU nephrolithiasis in dolphins is needed to optimize renal stone prevention and treatment. Smith *et al*. (2013b) believed that some populations are more likely to develop nephrolithiasis compared to others. Diagnostically, the presence or absence of stones was confirmed by ultrasonography and computed tomography. They finally concluded that the risk factors include hypocitraturia, hyperinsulinemia, geographic location, managed vs. free-ranging status, prey species, age and feeding schedules.

Post-renal obstruction secondary to bilaterally obstructing ureteral calculi was seen by ultrasound in an adult female bottlenose dolphin (Schmitt and Sur, 2012). To treat the obstruction, they applied two endoscopic procedures, cystoscopy for ureteral stent placement and ureteroscopy to perform intracorporeal lithotripsy on the obstructing calculi.

Cardiovascular system affections: Scaglione *et al*. (2013) have recorded number of cardiovascular pathologies in nine striped dolphins *Stenella coeruleoalba* and 1 bottlenose dolphin *Tursiops truncatus* from Italy. The pathologies included saccular aneurysms of the pulmonary trunk, cirsoid aneurysms, right ventricular dilation associated with hypoplasia of the tricuspid chordae, valvular fibrosis, mitral leaflet thickening, left ventricular hypertrophy, lymphocytic myocarditis and Lambl's excrescences. Some of these findings should be taken into account as possible causes of dolphin morbidity, mortality and stranding.

Using conventional, portable ultrasound systems without sedation (Sklansky *et al*., 2010) have implemented fetal echocardiography between 8-9 months gestation. They concluded that fetal echocardiography can provide a safe and detailed assessment of the cardiovascular status of the fetal bottlenose dolphin.

Dental affections: Pathological processes observed in the stomatognathic systems of mammalian species are a useful source of information about the habits, evolution and general health of such animals. Studies of pathological conditions on teeth are common in humans and other primates, but rare in wild animals in general and marine mammals in particular. Abnormalities such as caries-like lesions, mineralized calculus deposits, dental erosion, enamel anomalies, root resorption, germination and other shape anomalies, were diagnosed in dolphins (Loch and Simoes-Lopes, 2013).

Dental wear is a common phenomenon in mammals. Its occurrence is influenced by tooth anatomy, animal physiology, biomechanics and behavior (Loch and Simoes-Lopes, 2013). Frequencies of dental wear were high for all species of dolphins with exception of Delphinus capensis, with less than 50% of teeth worn. Whether dental wear has implications or not in fitness and feeding behavior, severely worn teeth may expose the pulp cavity and increase the susceptibility to local infections (Loch and Simoes-Lopes, 2013).

Digestive system affections: Diseases of the upper gastrointestinal tract, including ulceration, infection, parasitism and the effects of ingested foreign bodies are common in captive dolphins. Wirtschafter (1977) has used a per oral endoscopy for removal of a foreign body from the forestomach of a dolphin. Another case of foreign body retrieval from the stomach bottlenose dolphin was manually adopted by Beroza *et al*. (1981). Byard *et al*. (2010) have reported a fatal upper aerodigestive tract obstruction by an impacted Slender-spined Porcupine Fish and extensive respiratory tract papillomatosis in wild bottlenose dolphins. Denuncio *et al*. (2011) have reported that twenty-eight percent of the dolphins presented Plastic Debris (PD) in their stomach, but no ulcerations or obstructions were recorded in the digestive tracts. The PD ingestion was more frequent in estuarine (34.6%) than in marine (19.2%) environments, but the type of debris was similar. Packaging debris (cellophane, bags and bands) was found in 64.3% of the dolphins, with a lesser proportion (35.7%) ingesting fishery gear fragments or of unknown sources (25.0%).

Historically, cytologic evidence of gastric inflammation has constituted a marker of systemic illness in dolphins. In a field survey, Goldstein *et al*. (2012) have assessed the prevalence of moderate and severe gastric inflammation among Atlantic bottlenose dolphins (*Tursiops truncatus*). They reported that prevalence was 9.6-11% throughout the entire assessed populations. On microbiological examination they found no clinically significant aerobic-anaerobic or fungal culture results from gastric contents. Jaber *et al*. (2013) have described biliary cirrhosis produced by *Campula* spp. in 1 striped dolphin *Stenella coeruleoalba* and 4 harbor porpoises *Phocoena phocoena*. The hepatic lesions consisted of severe proliferation of fibrous connective tissue with loss of the lobular pattern, nodular regeneration of the hepatic tissue, bile duct hyperplasia and severe inflammatory infiltrate composed of eosinophils, macrophages, lymphocytes and plasma cells. Massive infestation by these parasites should be included as a cause of hepatic failure resulting in stranding of marine mammals.

Asphyxiation due to choking was identified as the cause of death in 4% of bottlenose dolphins (*Tursiops truncatus*) (Stolen *et al*., 2013). On necropsy, large number of dead dolphins have had some fish lodged in the anterior esophagus associated with a dislocated and blocked or compacted larynx. The fish species involved in choking comprised sheep shead, black chin tilapia and striped mojarra.

Another form of digestive disorders, which is relatively rare is the enterolith (intestinal calculus). Burdett and Osborne (2010) have found an enterolith completely obstructing the

intestinal lumen. Further, examination of the enterolith revealed a stingray spine nidus. Most terrestrial enteroliths are composed primarily of struvite (magnesium ammonium phosphate); however, the majority of the enterolith discovered in the stranded dolphin was composed of calcium phosphate carbonate (Burdett and Osborne, 2010).

Central Nervous System (CNS) affections: Central nervous system affections in marine mammals are numerous and mostly of infectious origin. The reports of bacterial infections of CNS goes back to the early seventies. Colgrove and Migaki (1976) have found an abscess in the right cerebral hemisphere in a captive Atlantic bottlenosed dolphin (*Tursiops truncatus*). The abscess was attributed to *Staphylococcus aureus* infection.

Brucella infection is the most common bacterial agents causing meningitis in dolphins and other cetaceans. *Brucella ceti* infection specific to the central nervous system has been described in two species of cetacean: striped dolphins (*Stenella coeruleoalba*) in Europe/Costa Rica and an Atlantic white-sided dolphin (*Lagenorhynchus acutus*) in the UK. *B. ceti*-associated meningitis and arthritis in a the short-beaked common dolphin (*Delphinus delphis*), in the UK was also reported (Davison *et al*., 2013).

Morbilliviral encephalitis in a free living striped dolphin *Stenella coeruleoalba* calf was recorded by Di Guardo *et al*. (2010). Significant neuropathological findings included non-suppurative meningoencephalitis, microgliosis, neuronal degeneration, astrocytosis and occasional multinucleate syncytia.

Severe, non-suppurative meningoencephalitis caused by toxoplasmosis was reported in striped dolphins on the Ligurian Sea coast of Italy (Di Guardo *et al*., 2010).

Reproductive system affections: Vaginal calculi have been described from the common (*Delphinus delphis*), Pacific white-sided (*Lagenorhynchus obliquidens*) and spotted (*Stenella attenuata*) dolphins (Woodhouse and Rennie III, 1991). The calculi represented spontaneous incomplete abortion with retention of part or all of the fetus in the distal reproductive tract. The form of the calculus relates to the degree of skeletal development at the time of fetal death. Calculi from a pregnant dolphin provided one measure of residence time.

Munson *et al*. (1998) have detected unusual cystic structures in the ovaries of several morbillivirus-infected Mediterranean striped dolphins (*Stenella coeruleoalba*) dolphins. These structures were identified as multiple leutinized cysts from their gross and histomorphologic characteristics. No morbillivirus antigens were detected in the lesions by immunohistochemistry.

CONCLUSION

The spectrum of surgical affections in dolphins is expanding due to the increasing anthropogenic activities, crowded maritime trafficking and catastrophic increase in marine environmental pollution. Affections are broadly categorized into physical injuries, deformities, genetic disorders and most critically the infectious diseases. Sewage pollution of marine environments presents a rich medium for development of infectious diseases, especially those with zoonotic potential. The strikingly developed immune system of dolphins that simulates their mammalian ancestors allow them to be highly adapted to contract most of the mammalian infectious agents with consequent similar immune response. The expanding scope of affections targeting dolphins, mandates the development of a modern/competent marine mammals medicine and surgery as an independent branch of exotic medicine.

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