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Author(s): Justin F. Rosenberg, D.V.M., Martin Haulena, D.V.M., M.Sc., Dipl. A.C.Z.M., James E. Bailey, D.V.M., M.S., Dipl. A.C.V.A.A., Dean A. Hendrickson, D.V.M., M.S., Dipl. A.C.V.S., Marina Ivančić, D.V.M., Dipl. A.C.V.R., and Stephen A. Raverty, D.V.M., M.Sc., Ph.D., Dipl. A.C.V.P.
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EMERGENCY ANESTHESIA AND EXPLORATORY LAPAROTOMY IN A COMPROMISED PACIFIC WHITE-SIDED DOLPHIN (*LAGENORHYNCHUS OBLIQUIDENS*)

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Abstract: Anesthesia and surgery in cetaceans have inherent risks and have rarely been utilized as viable treatment options. This report represents the first known multidisciplinary team approach to emergency laparotomy in a compromised, 22-yr-old, female Pacific white-sided dolphin (*Lagenorhynchus obliquidens*). The inciting clinical signs and ancillary diagnostics were consistent with a mechanical ileus. Although no torsion or obstruction was apparent during surgery, severe enteritis and peritonitis were noted. Postoperatively, the animal was maintained on aggressive medical management with continuous supportive care until succumbing 3 days later with clinical pathology indicative of terminal sepsis and profound inflammation. Postmortem findings included generalized vascular stasis and segmental intestinal volvulus with infarction. To the authors' knowledge, this is one of the most-complex surgical and anesthetic procedures performed in a cetacean. Though the outcome was unsuccessful, this case represents the aquatic veterinary community's collective advances in the ability to treat cetaceans under human care.

Key words: Anesthesia, intestinal volvulus, *Lagenorhynchus obliquidens*, laparotomy, Pacific white-sided dolphin, pathology.

BRIEF COMMUNICATION

Performing surgical procedures in cetaceans has resulted in high complication rates due to the unique anatomy and pathophysiology of these animals.[3,4] Advances in cetacean medicine have allowed for elective, minimally invasive procedures to be performed under general anesthesia with relatively low complications.[1] Abdominal surgeries are even less-frequently performed and the literature has a paucity of anecdotal case reports aside from the initial procedures performed in 1967.[6]

We provide the reader with evidence that emergency laparotomies can be performed in compromised or debilitated cetaceans. Rather than focus on the idiosyncrasies of cetacean anesthesia or the approach to sick cetacean case management, we highlight the cumulative advancements and current state of cetacean medicine, surgery, and anesthesia.

An approximately 22-yr-old, adult, female Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) maintained at the Vancouver Aquarium presented with acute onset anorexia, lethargy, disregard for behavioral cues, and decreased fecal output. Initial blood work was obtained for a complete blood count, serum biochemistry, fibrinogen, serum iron, and erythrocyte sedimentation rate (ESR). Although the animal was not housed with any male conspecifics, progesterone was also measured because there was a concern of pseudopregnancy given the animal's reproductive history. All results were compared to lifetime averages (LTA) for the animal and revealed a decreased leukocyte count (2.9×10^9 cells/L, LTA 3.4×10^9 cells/L), dehydration based on hemoconcentration (blood urea nitrogen [BUN] 13 mmol/L [LTA 11.8 mmol/L], creatinine 112 μmol/L [LTA 82 μmol/L], total protein 83 g/L [LTA 75 g/L]), and elevated total bilirubin 4.7

From the Vancouver Aquarium Marine Science Center, 845 Avison Way, Vancouver, British Columbia V6G 3E2, Canada (Rosenberg, Haulena); the Innovative Veterinary Medicine, Inc., P.O. Box 141140, Gainesville, Florida 32614, USA (Bailey); the College of Veterinary Medicine and Biomedical Sciences, Colorado State University, 1678 Campus Delivery, Fort Collins, Colorado 80521, USA (Hendrickson); the AquaVetRad, 1750 Kettner Boulevard, San Diego, California 92101, USA (Ivančić); and the Animal Health Centre, British Columbia Ministry of Agriculture, 1767 Angus Campbell Road, Abbotsford, British Columbia, V3G 2M3 Canada (Raverty). Present address (Rosenberg): Department of Small Animal Clinical Sciences, College of Veterinary Medicine, University of Florida, 2015 S.W. 16th Avenue, Gainesville, Florida 32608 USA; Present address (Ivančić): Brookfield Zoo/Chicago Zoological Society, 3300 Golf Road, Brookfield, Illinois 60513, USA. Correspondence should be directed to Dr. Rosenberg (rosenbergdvm@gmail.com).

μmol/L [LTA 3.2 μmol/L]). Samples were collected from the rectum, vagina, and blowhole but revealed no cytologic evidence of disease.

The animal was started on aggressive medical management that included metronidazole (AA Pharma Inc., Toronto, Ontario L4K 4N7, Canada, 10 mg/kg p.o. b.i.d.), ciprofloxacin (Mylan Pharmaceuticals ULC, Etobicoke, Ontario M8Z 2S6, Canada; 10 mg/kg p.o. b.i.d.), and prednisone (Teva Pharmaceutical Industries Ltd., Toronto, Ontario M1B 2K9, Canada; 0.2 mg/kg p.o. s.i.d.). The following day, ranitidine (Sandoz Canada Inc., Boucherville, Quebec J4B 7K8, Canada; 2 mg/kg p.o. b.i.d.), maropitant (Zoetis Canada Inc., Kirkland, Quebec H9H 4M7; 1 mg/kg p.o. s.i.d.), and diazepam (Apotex Inc., Toronto, Ontario M9L 1T9, Canada; 0.1 mg/kg p.o. s.i.d.) were added. Blood work was repeated and revealed decreased leukocytes (1.9×10^9 cells/L) with a normal differential, ongoing azotemia (BUN 15.4 mmol/L, creatinine 123 μmol/L), markedly elevated total bilirubin (10 μmol/L), and grossly icteric serum.

The third day after presentation, the animal's hemogram revealed toxic change with a mild left shift. Serum chemistry was mostly static compared to the previous days' results, but iron continued to decrease (7.1 μmol/L [LTA 35.6 μmol/L]) while fibrinogen increased (2.5 g/L [LTA 2 g/L]). Itraconazole (Janssen Inc., Toronto, Ontario M3C 1L9, Canada; 5 mg/kg p.o. s.i.d.) and nystatin (Teva Pharmaceutical Industries Ltd.; 5,000 IU/kg p.o. s.i.d.) were added. Abdominal ultrasonography (GE Logiq E with 4C-RS 2-5.5 MHz curvilinear probe, General Electric Company, Milwaukee, Wisconsin 53201, USA) identified a fluid-distended forestomach and severe fluid distension of small bowel loops. There was a moderate amount of anechoic peritoneal effusion. Horizontal beam abdominal radiographs (TruDR™ 4030, Sound-Eklin, Carlsbad, California 92011, USA) out of the water revealed numerous dorsally displaced, gas-distended small bowel loops containing horizontal fluid lines. Dorsal displacement of the bowel was suspected to be from dependent accumulation of peritoneal effusion. An enema resulted in expulsion of necrotic debris and frank hemorrhage. There was a working diagnosis of intestinal torsion or severe enteritis, and medical management continued.

That evening, the dolphin was sedated with midazolam (Pharmaceutical Partners of Canada Inc., Richmond Hill, Ontario L4B 3P6, Canada; 1 mg/kg i.m.) to facilitate ultrasound-guided intravenous catheter placement into the left lateral caudal subcutaneous vein via techniques previously described.[5] An IV fluid bolus (0.9% NaCl, Baxter Corporation, Mississauga, Ontario L5N 0C2, Canada) and ceftriaxone (Steri-Max Inc., Mississauga, Ontario L4W 4M8, Canada; 20 mg/kg i.v.) were administered. Due to concerns of deteriorating gastrointestinal function, intravenous delivery replaced oral medications.

The following day, a repeated ultrasonographic examination identified progressive disease with a significantly fluid-distended forestomach, fundic chamber, fluid and ingesta-dilated intestinal loops, and bicavitary (pleural and peritoneal) effusion. Cytologic findings from abdominocentesis revealed a modified transudate (4,230 nucleated cells, PCV 6%, total protein 30 g/L) with predominantly macrophages and phagocytized erythrocytes. There was also a dramatic increase in the relative amount of peritoneal effusion. The blood work reflected these findings—anemia (red blood cells 4.3×10^9 cells/L [LTA 5.8×10^9 cells/L]; PCV 42% [LTA 58%]), ESR 7 mm/hr (LTA 0 mm/hr), fibrinogen 3.9 g/L, and serum iron 14.9 μmol/L. Based on the clinicopathologic findings, the diagnostic imaging consistent with mechanical ileus, rapid deterioration of clinical condition, and the lack of bowel movements since presentation, the decision was made to pursue an emergency exploratory laparotomy.

The dolphin was induced with propofol (Fresenius Kabi Canada Ltd., Richmond Hill, Ontario L4B 3P6, Canada; 4.8 mg/kg i.v. to effect), intubated orally following manual displacement of the goosebeak, and maintained on sevoflurane (Abbvie Corporation, Saint-Laurent, Quebec H4S 1Z1, Canada) between 2–4% with an oxygen flow rate of 10 L/min via conventional controlled mechanical ventilation. Constant monitoring of vital signs including electrocardiography, capnography, and inspired–expired gas was performed for the duration of the procedure. Serial blood gas analyses were monitored throughout the anesthetic event. Surgical exploration was performed through an 18-cm left ventrolateral flank incision that extended through skin, blubber, muscle, and peritoneum. Although full examination of viscera (liver, spleen, kidneys) was not able to be performed, a thorough examination of the gastrointestinal tract was completed. No torsion, volvulus, intussusception, foreign body, or obstruction was appreciated; however, the orad sections of small intestine were severely hemorrhagic, dark in coloration, and distended with fluid. The mesentery was dark red; however, all

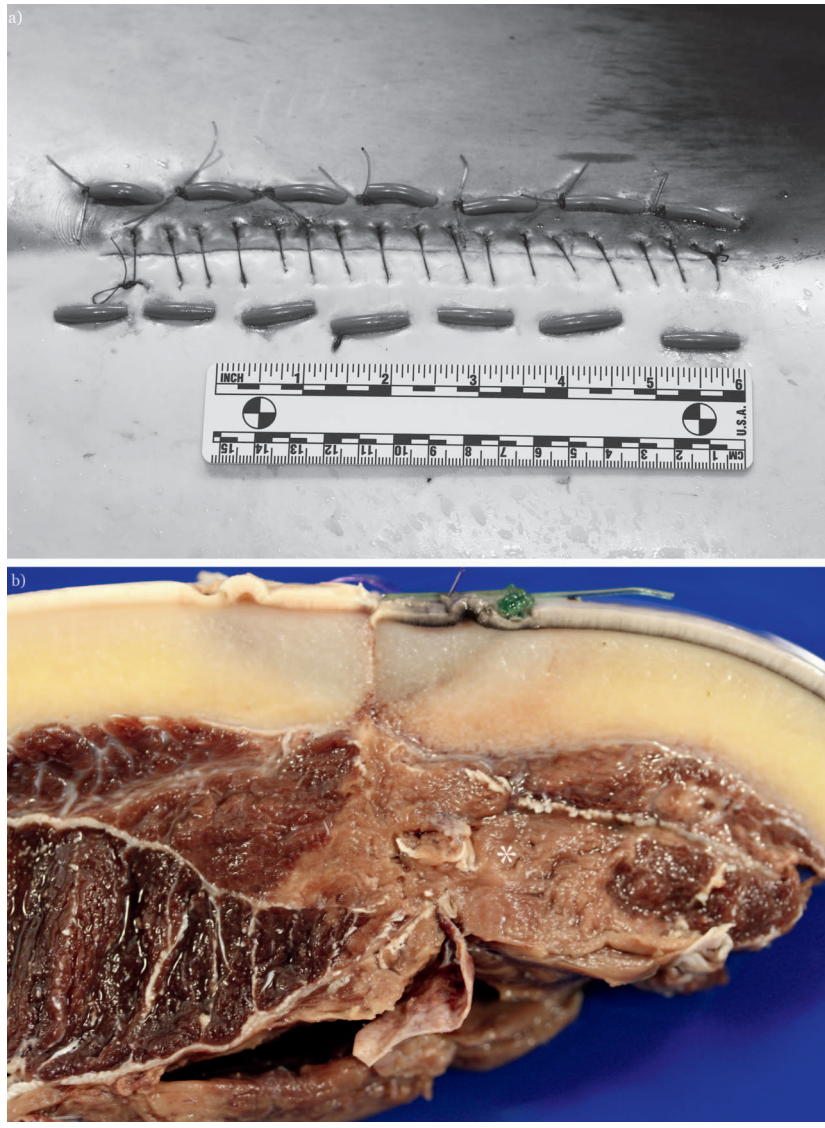

Figure 1. Left ventrolateral flank incision with tension-relieving sutures in the Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) following exploratory laparotomy viewed from (**a**) external and (**b**) internal orientations. Internal aspect shows a transverse section of the incision site with necrosis of the abdominal musculature, denoted by *.

vessels had a palpable pulse. The serosal surface of the affected intestine had petechial and ecchymotic hemorrhage. Several sections of proximal bowel were extremely taut and distended with gas and fluid and were "milked" into the caudal portion of small intestine. The decision was made to recover the animal rather than pursuing euthanasia. Four-layer closure was performed including three layers of abdominal wall muscle, using size 0 polyglyconate (Medtronic Maxon™, Covidien Canada, Saint-Laurent, Quebec H4S 1Z1, Canada) in a simple continuous pattern and tension-relieving sutures with sterile 60# test monofilament fishing line and red rubber catheter stents through the skin and blubber (Fig. 1). A second intravenous catheter was placed cranial to the first catheter, within the same vessel, after multiple unsuccessful attempts were made at cannulation of the right lateral caudal subcutaneous vein, given the patient's positioning for surgery. The animal had a prolonged recovery, requiring reintubation three times, but was ulti-

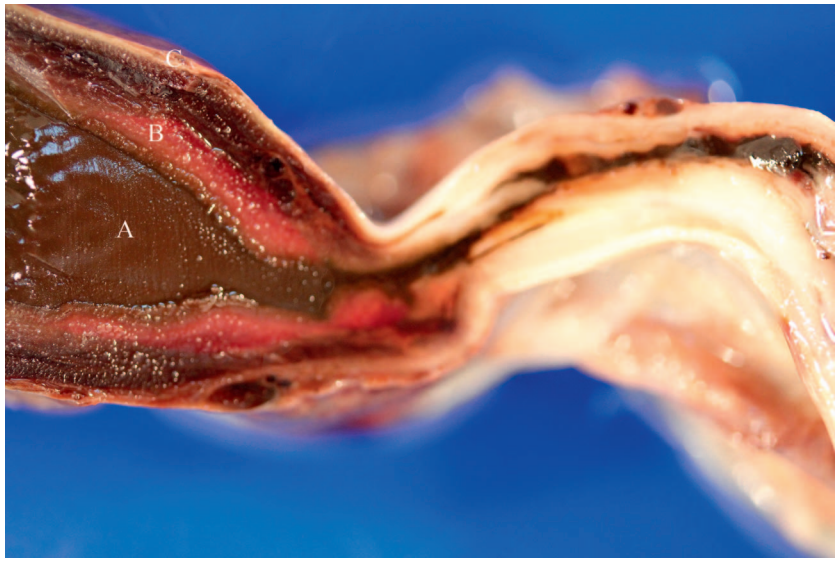

Figure 2. Caudal limit of infarcted bowel, with luminal distention by frank hemorrhage and transmural edema at the ileocecal junction, and with progressively tapering caudad luminal stenosis in a Pacific white-sided dolphin (*Lagenorhynchus obliquidens*). **A** indicates the frank hemorrhage within the lumen; **B** is transmural–submucosal edema; **C** is the serosal edge of the distal ileum.

mately placed back into water. With the exception of diagnostic procedures, intravenous catheter placement, and surgical intervention, the animal was maintained in a medical pool with adjustable water depth that was separate from the main habitat; postoperatively the dolphin was unable to swim and required constant external support (i.e., staff members physically holding the animal) at all times.

Following surgery, daily blood work was analyzed and revealed a progressive inflammatory leukogram with evidence of sepsis. Postoperative medications included metoclopramide (Sandoz Canada Inc.; 0.1 mg/kg i.v. b.i.d.), ceftriaxone (Steri-Max Inc.; 20 mg/kg i.v.), metronidazole (Hospira Healthcare Corporation, Montreal, Quebec H4M 2X6, Canada; 10 mg/kg i.v.), tramadol (Apotex Inc.; 2 mg/kg p.o. b.i.d.), meloxicam (Apotex Inc.; 0.1 mg/kg p.o. b.i.d.), and 0.9% NaCl IV fluid boluses. Within 12 hr of anesthetic recovery, the animal began eating and passed a small amount of dark, loose stool.

Over the course of the next 3 days, the hemogram deteriorated while ESR (30 mm/hr), fibrinogen (6.4 g/L), and lactate (8.5 mmol/L [no lifetime average available]) increased. Additional medications including amikacin (Wyeth Canada, Guelph, Ontario N1K 1E4, Canada; 7 mg/kg i.v. once followed by 4 mg/kg p.o. s.i.d.), ertepenam (Merck Canada Inc., Kirkland, Quebec H9H 4M7; 8 mg/kg i.v.), furosemide (Intervet Canada Ltd., Whitby, Ontario L1N 9T5; 0.5 mg/kg i.v.), and lidocaine continuous rate infusion (Zoetis Canada Inc.; 0.5 mg/kg/hr following 1 mg/kg i.v. bolus) were added. Despite critical care and surgical intervention, the dolphin died 3 days after surgery and 6 days after onset of clinical signs.

Gross necropsy and histopathology were consistent with the proximate cause of death as distal ileum intestinal volvulus and segmental infarction with septic shock. Extending from the aborad limit of the affected segment of infarcted bowel to the ileocecal junction, there was massive submucosal hemorrhage and edema with progressively tapering caudad luminal stenosis (Fig. 2). The degree of orad intestinal distention with frank hemorrhage, combined with an aborad lack of luminal hemorrhage or colonic contents, suggested that the obstruction was acquired following surgery. There was no indication of intussusception, stricture, foreign body, or other pre-existing condition at necropsy that may have resulted in this process. There was adhesion of two loops of bowel, proximal to the volvulus, to the internal aspect of the dehisced incision site, and it is possible that this may have provided a fulcrum or disrupted normal peristaltic movements, which contributed to intestinal volvulus and incarceration. Although the cutaneous margins of the incision site were apposed and appeared grossly

normal, the skeletal muscles subjacent to the incision were segmentally pale and friable, consistent with coagulative necrosis. The margins of the adjacent peritoneum were retracted from the internal aspect of the incision and the defect was multifocally overlaid with fibrinoserous exudate. The bicavitary effusion appreciated ante- and postmortem may be attributed to the cumulative effects of generalized cardiovascular decompensation, sepsis, cytokine activation, and polyserositis. Postmortem abdominocentesis cultured *Escherichia coli* and *Clostridium perfringens* α-toxin was recovered from heart blood.

The necropsy findings of intestinal volvulus and infarction may have obscured evidence of a spontaneously reducing antemortem intestinal incident prior to surgery. Intestinal volvulus has been reported in free-ranging cetaceans as well as those under human care with multifactorial and variable predisposing factors.[2] The significance of *C. perfringens* α-toxin in this case is unknown. Given the anaerobic conditions in an infarcted segment of bowel, clostridia can proliferate secondary to volvulus; it is difficult to determine the contribution of this isolate in the pathogenesis of this animal's condition.[2]

Although the outcome was undesirable, this case represents the aquatic veterinary community's collective advances in the ability to surgically intervene or treat cetaceans under human care. The early pioneering work of anesthesia in cetaceans[6] has allowed modern-day clinicians to provide cetaceans with advanced medical care that is considered standard practice in domestic species. This case highlights the fact that a severely compromised cetacean can survive an anesthetic procedure.

Anecdotally, laparoscopic techniques have been developed and can be applied to the cetacean patient. However, there are certain circumstances where an open abdominal approach may be indicated. The aquatic animal veterinarian should be aware of all risks involved in these procedures, but perioperative medical and anesthetic management have progressed to enable advanced and emergent surgical interventions in cetaceans with improved outcomes.

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