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Asystole and intraoperative resuscitation following a large abdominal mass removal in a wild boar (*Sus scrofa*)

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Abstract: *An 11-year old, 100-kg female wild boar (Sus scrofa L.) was presented with an abnormal vulvar bleeding during the previous month. The patient was sedated at the referring zoo with medetomidine and tiletamine-zolazepam to perform transabdominal ultrasound, which revealed a mass in the enlarged uterus, and the sow was scheduled for ovariohysterectomy. After propofol anaesthetic induction, general anaesthesia was maintained with isoflurane vaporized in oxygen, and a constant rate infusion of fentanyl was administered to provide intraoperative analgesia. During uterus removal, the sow suffered severe bradycardia and subsequent cardiac arrest. Extraction of a large mass from the abdomen potentially resulted in high haemodynamic imbalance like distributive shock and haemorrhagic shock, and eventually asystole. Cardiopulmonary resuscitation was performed. The Reassessment Campaign on Veterinary Resuscitation (RECOVER) guidelines were followed. Anaesthesia was discontinued and the resuscitation procedure combined chest compressions and mechanical ventilation. In addition, both single doses of adrenaline and atropine were administered. Return to spontaneous circulation was accomplished and the surgical procedure could be completed. In conclusion, removal of a large, 7.2-kg, abdominal mass was associated with cardiopulmonary arrest where current recommendations for cardiopulmonary resuscitation were applied and demonstrated to be effective in a wild boar undergoing general anaesthesia.*

I. Introduction

Removal of large masses from the abdominal cavity may be associated with a sudden reduction of venous return, thus promoting parasympathetic activation leading to severe bradycardia and hypotension [1, 2] or even cardiopulmonary arrest (CPA), likely favoured by a poor health status [3-6]. However, cases reporting CPA following removal of a large abdominal mass in the veterinary literature are sparse. Cardiopulmonary resuscitation (CPR) should be immediately started after CPA recognition, by means of providing chest compressions and artificial ventilation. Evidence suggests the relevance of early and continuous delivery of

high-quality chest compressions with minimal interruption [7, 8]. Recent guidelines (Reassessment Campaign On Veterinary Resuscitation, RECOVER) have been established, based on expert consensus considering the reported evidence from the veterinary literature on CPR in dogs and cats [8]. This case report describes the occurrence of cardiac arrest after removal of a severely enlarged uterus in a wild boar undergoing ovariohysterectomy, and the application of CPR according to recent recommendations.

II. Case description

An 11-year-old, 100-kg, wild boar and housed in a referring zoo (Zoo Aquarium de Madrid), presented intermittent vulvar blood discharge lately. The patient exhibited general weakness, anorexia and depressed demeanour over the last two days before presenting to the veterinary teaching hospital. Further pre-anaesthetic evaluation should have included physical examination and laboratory blood work, although physical restraint and handling of the patient was not possible, thus requiring chemical restraint for blood sampling and safe transfer to the hospital.

Sedation was performed at the referring zoo with a combination of tiletamine and zolazepam (TZ; Zoletil 100, Virbac) and medetomidine (Dorbene 1 mg/mL, Zoetis), administered intramuscularly (IM) in the neck by blowpipe darting. Two additional IM injections of sedation were necessary to achieve unresponsiveness of the sow and allow transportation. Total doses (TD) were 4+4 mg/kg of tiletamine+zolazepam and 0.2 mg/kg of medetomidine.

Upon admission at the hospital, the sow was deeply sedated and 2% isoflurane (Vetflurane, Virbac) vaporized in oxygen was administered by facemask to facilitate intravenous (IV) 20-G catheter placement in the auricular vein. Fluid therapy with lactate's Ringer solution (LRS; Lactato Ringer, BBraun; 10 mL/kg/h) was started. Transabdominal ultrasound revealed an enlarged uterus suggesting the presence of abnormal content. Differential diagnosis included neoplastic endometrial disease and urgent ovariohysterectomy was scheduled while the sow was still anesthetized.

General anaesthesia was induced with propofol (Propofol Lipuro 1%, BBraun; 0.9 mg/kg IV) while isoflurane was given in oxygen via facemask (3 L/min). The larynx was sprayed with lidocaine (Xilonibsa 10%, Inibsa; 20 mg TD). The trachea was intubated with a 12-mm cuffed endotracheal tube and connected to a circular rebreathing anaesthetic system. Anaesthesia was maintained with isoflurane (end tidal 1-1.5%) vaporized in oxygen in the preparation room. The patient was then transferred to the theatre and connected to an anaesthetic workstation (Julian, Dräger), with isoflurane in oxygen and air (50:50, 1 L/min) as anaesthetic maintenance. Spontaneous breathing was allowed, but ten minutes after the start of surgery a fentanyl (Fentadon 50 µg/mL, Dechra; 5 µg/kg/h IV) continuous rate infusion (CRI) was administered, and mechanical ventilation was provided to maintain normocapnia. Volume-controlled ventilation settings were: tidal volume 10 mL/kg, respiratory rate (RR) 5-10 breaths per minute (bpm), and positive end expiratory pressure 5 cmH_2O, producing a peak pressure of 20 cmH_2O. Meloxicam (Metacam 20 mg/mL, Boehringer-Ingelheim; 0.4 mg/kg) was administered to provide additional analgesia.

Monitoring initially included electrocardiogram, RR by observing chest movements, and rectal temperature. Once the patient was transferred to the theatre oxygen saturation of haemoglobin (SpO_2, pulseoximetry), non-invasive blood pressure (NIBP, oscillometric) with the cuff placed on the metatarsus, capnography ($EtCO_2$) and end tidal isoflurane (Et_{ISO}) were also monitored during surgery (Julian, Dräger). Unsuccessful attempts were made for the placement of an arterial catheter in the auricular artery for invasive blood pressure and blood gas monitoring.

Non-invasive mean arterial pressure (MAP) consistently showed hypotension (55 mmHg) over 30 minutes at the preparation room until transfer to theatre. Five minutes after starting surgery, blood pressure monitoring failed during a 15-minute period despite continuous attempts. In the meantime, while surgeons were removing the uterus weighing 7.2 kg, a sudden 20%-increase in heart rate (HR) was observed and a fentanyl top-up (5 µg/kg IV) was administered. Soon after, HR and $EtCO_2$ decreased suddenly within seconds, until asystole was established, and CPA diagnosed.

Immediately the vaporizer was closed, oxygen flushed into the breathing circuit, fentanyl CRI discontinued, and Basic Life Support (BLS) started following the RECOVER guidelines. The sow was placed in lateral recumbency and an experienced anaesthesiologist (MA) initiated chest compressions over the widest portion of

the chest using the 2-handed technique, at 100-120 compressions per minute. The RR was set at 10 bpm and oxygen provided at 100%. Mechanical ventilation was maintained during CPR.

Low adrenaline dose (Adrenalina 1 mg/mL, BBraun; 0.01 mg/kg IV) and atropine (Atropina 1 mg/mL, BBraun; 0.02 mg/kg IV) were administered. Effectiveness of compressions was checked through capnography, showing $EtCO_2$ values above 15 mmHg. After a 2-minute period of chest compressions, ECG was checked with asystole still present. Thus, a second trained person (IAG) continued chest compressions and a second low adrenaline and atropine doses were administered. Return of spontaneous circulation (ROSC) occurred during the second 2-minute cycle of chest compressions when $EtCO_2$ reached 34 mmHg and electrical cardiac activity returned to sinus rhythm.

After ROSC, palpation of the auricular arteries revealed a weak pulse suggesting hypotension. Therefore, dopamine (Dopamina, Grifols; 5 µg/kg/min) and hypertonic saline (Hipertónico salino 7,5%, BBraun; 2 mL/kg in 50 minutes) were administrated concomitantly to the LRS. Arterial blood pressure (ABP) monitoring remained ineffective until 30 minutes post-ROSC. Isoflurane was not provided until MAP was above 70 mmHg when Et_{ISO} was set between 0.5 and 0.8%. At this time the patient started breathing against the ventilator and spontaneous ventilation was allowed with $EtCO_2$ remaining within normal values (35 – 45 mmHg) until the end of anaesthesia.

The surgical procedure was challenging because of excessive bleeding, although ovariohysterectomy and closure of laparotomy were successfully accomplished. Total surgery time was 123 minutes and total anaesthesia time, from induction to vaporizer closure, was 150 minutes. Extubation occurred ten minutes later and atipamezol (Alzane 5 mg/mL, Zoetis; 0.1 mg/kg IM) was administered. The sow showed voluntary eye movement and regained sternal recumbency 15 minutes following extubation.

The referring veterinarian considered transportation to the zoological care unit. Upon arrival to the zoo, an additional dose of atipamezol was administered (0.2 mg/kg IM) and the patient slowly recovered although it was unable to stand up until the next day. Postoperative analgesia was provided every 24 hours PO with tramadol (2 mg/kg, 3 days) and meloxicam (0.4 mg/kg, 10 days). Hind limb weakness was observed for two days postoperatively but the patient evolved satisfactorily thereafter and completely recovered within one month.

Preoperative blood analysis (Table 1), available postoperatively, showed hyperglycaemia, hyponatraemia and hyperkalemia (396 mg/dL, 128 mEq/L and 7.71 mEq/L, respectively). Blood urea nitrogen (BUN) levels were 23.1 g/dL. The pathologic diagnosis revealed uterine leiomyoma and cystic endometrial hyperplasia with moderate suppurative multifocal endometritis.

III. Discussion

The removal of an enlarged uterus in a debilitated wild boar undergoing general anesthesia likely promoted severe hemodynamic alterations due fluid shift likely associated with dehydration, eventually producing cardiac arrest. Although there are no published CPR guidelines in swine, adherence to RECOVER guidelines developed for dogs and cats [8] were considered and successful CPR was achieved. Sudden abdominal decompression has also been associated to cardiac arrest in a woman with successful recovery [9].

Differential diagnoses for the abnormal imaging of the uterus in this patient were based on previous reports in swine such as miniature swine or pot-bellied Vietnamese pigs, including cystic endometrial hyperplasia, endometrial adenocarcinoma, leiomyomas, leiomyosarcomas and pyometra [10-12]. Although not reported in wild boars, ovariohysterectomy is the suggested procedure in other species [13, 14].

Capturing and handling of wild animal species may be challenging and dangerous, frequently requiring physical and chemical restrain. Common anaesthetic protocols in wild boars include combinations of ketamine-like anaesthetics and sedatives such as α2-adrenergic agonists [15]. The combination of TZ and medetomidine provides a safe and efficient anaesthetic combination to capture wild boars [15]. Both medical history and the poor physical condition of the sow suggested an increased anaesthetic risk, but the difficulty in handling and transferring to the hospital required deeper sedation than expected. Three doses within 60 minutes were required suggesting they were adequate avoiding overdosing in a sick animal.

Isoflurane (2%) vaporized in oxygen was used both to oxygenate and to maintain deep sedation allowing venous catheterization. Isoflurane anaesthetic induction was not considered as it may induce severe hypotension in hypovolemic patients [16]. Alternatively, propofol was used to induce general anaesthesia after deep sedation

in wild boars [17]. Endotracheal intubation in swine is considered more complicated compared to dogs or cats; however, in the present case, the technique was carried out by an experienced anaesthetist (MA) placing the animal in sternal recumbency and applying laryngeal lidocaine before placing the tube into the trachea [18].

Current flow rate recommendations for fluid therapy in healthy patients during anaesthesia range between 3 and 5 mL/kg/h in cats and dogs [19], respectively, while no recommendations have been reported for wild boars. However, recent sow's history suggested a poor health status including chronic haemorrhage, malnutrition and weakness, suggesting dehydration. Thus, a higher crystalloid-based flow rate (10 mL/kg/h) was considered to improve circulating volume.

Mechanical ventilation may have deleterious effects on venous return and therefore be discouraged in patients at risk for haemodynamic instability [20]. In order to reduce impact on venous return, setting of higher tidal volumes and positive end expiratory pressure were avoided. However, ventilatory depression, most likely produced by fentanyl administration and reduced respiratory compliance due to the bulky abdominal content, suggested the provision of mechanical ventilation to ensure normocapnia in this case. Increased abdominal pressure caused by the enlarged uterus may have accounted for further reductions in venous return [21].

Direct ABP monitoring was considered but attempts to arterial catheterization placement failed. While NIBP provide confident values in normotensive pigs [22], sudden changes in ABP cannot be assessed and are unreliable in hypotensive patients. Blood pressure readings indicated low ABP and failed for 15 minutes just before fentanyl top-up was administered. The sudden increase of HR could have been a response to maintained hypotension and not to noxious stimulation, as it was initially considered. Therefore, several causes of asystole may be considered including not only fentanyl administration [23], but also an additive effect of reduced venous return, haemorrhage, dorsal recumbency and bradycardia leading to severe hypotension [1, 24]. Viscera manipulation and uterus extraction should be considered a relevant factor, which may have triggered a vagal reflex followed by asystole [25-28]. Such manipulation may also have promoted a sudden occlusion of the caudal vena cava, likely involving a Bezold-Jarisch reflex-like reaction [2, 24].

Anticipated treatment of hypotension with fluids or vasomotor drugs would have been desirable as ABP monitoring was lacking and hypotension was most likely occurring. Other factors may account for this life-threatening arrhythmia such as the sow's previous weak status, insufficient preoperative fluid therapy, lack of pre-anaesthetic stabilization, and the sedative and anaesthetic doses administered. Laboratory results revealed previous hyperkalemia which should be considered an additional cause favouring ventricular asystole, however these results were not available until the postoperative period. Concurrent hyperkalemia and hyponatremia might also be related to dehydration with liquid redistribution to third spaces like abdomen [29].

Recent veterinary CPR recommendations are included in the RECOVER initiative, where evidence-based guidelines have been developed for dogs and cats [8]. Immediate BLS was applied with chest compressions and provision of ventilation. However, fully adherence to RECOVER recommendations was not followed. For instance, Advanced Life Support recommendations include administration of antagonists to reverse sedatives and analgesics, but they were not given at this stage. This fact might be relevant as fentanyl may have contributed to CPA and re-occurrence of CPA was likely to occur while ABP remained low for almost half an hour. Besides, a second dose of either adrenaline (0.01 mg/kg IV) or atropine (0.04 mg/kg IV) should be administered after two 2-minutes cycles, while a second adrenaline dose was administered before ROSC in this case, i.e. sooner than recommended. Although a rapid ROSC was achieved, lack of full adherence to RECOVER guidelines suggests a lack of leadership or communication in the present case. Organized crash carts, algorithm charts and CPR techniques and leadership training would have been desirable here as may improve patients' outcome when CPR is instituted [30].

Atropine administration during CPA is still controversial although recommended when a high vagal tone associated with CPA is suspected [8, 27, 28]. Provision of 100% oxygen following CPA has been questioned as it may produce reactive oxygen species and worsen neurological outcome compared to 21% inspired oxygen [31]. However, the risk of hypoxaemia was considered to be higher than the risk of hyperoxaemia given the inability to monitor blood gases to check oxygenation in the current case.

Hypertonic saline aimed to restore intravascular volume and is recommended during the initial treatment of severe haemorrhage [19]. This fluid increases resuscitation outcomes and survival rates when administered during and following CPA in experimental pigs [32]; however, the rate administered may had been eventually

too slow [19]. Moreover, choices for fluids for restoring intravascular volume when hypovolemia is due to haemorrhage are blood products or, alternatively, colloids better than crystalloids [19, 33]. As low ABP values were expected following CPA and monitoring failure occurred, a dopamine CRI was considered to increase cardiac contractility and output [34].

Although transferring the patient to an intensive care unit would have been advisable, the referring veterinarian considered transfer to the zoo nurse unit, given the difficulties concerning handling, where atipamezole was employed to reverse the residual actions of medetomidine [15], and analgesics (meloxicam, tramadol) were provided for the postoperative period.

High glucose levels are common under medetomidine sedation, which reduces insulin release from the pancreas [35], and no further actions were considered to treat hyperglycaemia. High potassium levels in this patient could be related to initial pre-renal dysfunction. Unfortunately, difficulties regarding handling made impossible laboratory blood work follow up, as anaesthesia was discouraged given the patient's weakness during the postoperative period in the present case.

Pathological diagnosis revealed uterine leiomyoma and cystic endometrial hyperplasia with moderate suppurative multifocal endometritis. The development of reproductive tract lesions is commonly observed in nulliparous aged pig females [12].

IV. Conclusion

In conclusion, CPA occurred during the extraction of an enlarged uterus in a wild boar under general anaesthesia. Prompt CPR following current resuscitation recommendations in veterinary patients was successful.

V. Table

Table 1. Hematology and biochemistry values

PARAMETER	PATIENT'S VALUES	REFERENCE VALUES IN WILD BOAR
RBC (1012/L)	4.34	3.73 – 9.26
Haemoglobin (gr/dl)	10.8	8.4 – 17.1
Haematocrit % /PCV %	35.2	25.1 – 53.4
MCV (fL)	81.11	43.7 – 74.1
MCH (pg)	24.88	16.7 – 24.5
MCHC (g/dl)	30.68	29.5 – 37.7
WBC (109/L)	13.5	3.5 – 25.0
Neutrophils 109/L	12.42	1.01 – 12.58
Lymphocytes 109/L	1.08	1.55 – 13.15
Monocytes 109/L	0	0.07 – 1.60
Eosinophils 109/L	0	0.04 – 1.39
Basophils 109/L	0	Mean value 0.16
Platelets (109/L)	289	86 - 527
Glucose(mg/dl)	396	60 – 162
BUN (mg/dl)	23.03	2.5 – 20
Creatinine (mg/dl)	2.09	0.5 – 2.4
Cholesterol (mg/dl)	92	21 - 125
Triglyceride (mg/dl)	113	Mean value 43
Total protein (g/dl)	5.4	5.1 – 8.6
Albumin (g/dl)	2.8	0.5 - 5.3
Globulin (g/dl)	2.6	1.2 – 4.5
Albumin/Globulin	1.1	Mean value 1.3
Alk. Phosphatase (U/L)	23	2 - 220
Total bilirubin (mg/dl)	0.23	0.0 - 0.7

ALT (U/L)	16	13 - 119
AST (U/L)	17	12 - 76
Gamma GT (U/L)	-	1 – 78
CK (U/L)	264	0 - 1968
Calcium(mg/dl)	8.8	8.4 - 12.7
Phosphorus (mg/dl)	7.3	3.9 – 11.3
Sodium (mEq/l)	128	133 - 157
Potassium (mEq/l)	7.71	3.4 - 6.5
Chloride (mEq/l)	94	94 - 117

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VII. Conflict of interests

The Authors declare that there is no conflict of interest.

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