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TOTAL INTRAVENOUS ANESTHESIA IN A MINIATURE SWINE UNDERGOING REGIONAL MASTECTOMY: A CASE REPORT

Anestesia total intravenosa em suíno miniatura submetido à mastectomia regional: relato de caso

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Abstract

Anesthesia in domestic pigs represents a challenge in veterinary practice and is essential for clinical, outpatient, diagnostic, and surgical procedures. This case report describes the anesthetic management of a 13-year-old female miniature pig weighing 94 kg that underwent regional mastectomy for the removal of mammary carcinoma. The anesthetic protocol consisted of intramuscular (IM) administration of xylazine (0.7) mg/kg), followed by intravenous (IV) administration of ketamine (2 mg/kg) and midazolam (0.1 mg/kg). Anesthetic induction was performed in the operating room using 1 mg/kg of propofol, 3 mcg/kg of fentanyl, and 0.5 mg/kg of lidocaine. Anesthesia was maintained with continuous propofol infusion at variable rates (0.05 to 0.1 mg/kg/min), together with analgesic infusions of fentanyl at 3 mcg/kg/h, ketamine at 0.2 mg/kg/h, and dexmedetomidine at 0.3 mcg/kg/h. The patient remained hemodynamically stable throughout the procedure, demonstrated a safe anesthetic recovery, and achieved adequate analgesic control. Intensive postoperative monitoring contributed to a favorable clinical outcome, demonstrating the effectiveness of the adopted protocol.

Keywords: swine; propofol; TIVA; multimodal anesthesia.

Resumo

A anestesia em suínos domésticos representa um desafio na prática veterinária, sendo fundamental em procedimentos clínicos, ambulatoriais, diagnósticos e cirúrgicos. O presente relato descreve o manejo anestésico de uma fêmea suína miniatura, com 13 anos e 94 kg, submetida à mastectomia regional para remoção de carcinoma mamário. Ao protocolo anestésico, foi instituída 0,7 mg/kg de xilazina por via intramuscular (IM), seguida de 2 mg/kg de cetamina associada a 0,1 mg/kg de midazolam, administrados pela via intravenosa (IV). A indução anestésica foi realizada no centro cirúrgico com 1 mg/kg de propofol, 3 mcg/kg de fentanil e 0,5 mg/kg de lidocaína. A anestesia foi mantida com infusão contínua de propofol em taxas variáveis (0,05 a 0,1 mg/kg/min), juntamente com infusões analgésicas de 3 mcg/kg/h de fentanil, 0,2 mg/kg/h de cetamina e 0,3 mcg/kg/h de dexmedetomidina. A paciente permaneceu hemodinamicamente estável durante todo o procedimento, apresentou recuperação anestésica segura e controle antálgico adequado. O acompanhamento intensivo no pós-operatório contribuiu para a boa evolução clínica, evidenciando a eficácia do protocolo adotado.

Palavras-chave: suínos; propofol; TIVA; anestesia multimodal.

Introduction

The performance of diagnostic, clinical, and surgical procedures in pigs depends on safe and effective anesthetic protocols, particularly in animals intended for production (De Monte *et al.*, 2015). With the advancement of veterinary medicine for non-conventional animals, miniature pigs have increasingly been adopted as companion animals, broadening the scope of anesthetic practice in this species. In addition, pigs are widely used in medical research due to their physiological similarity to humans (Costea; Ene; Pavel, 2023).

Despite the use of pigs in different clinical and experimental settings, anesthesia in this species remains a significant challenge. Their reactive behavior and high levels of stress often make physical restraint difficult, which may compromise animal welfare and procedural safety (De Monte *et al.*, 2015). Furthermore, procedures requiring general anesthesia necessitate tracheal intubation, and airway access is hindered by the anatomical characteristics of the upper airways, such as an elongated snout, a thick and bulky tongue, a narrow oropharyngeal cavity, and an elongated soft palate. In addition, pigs are prone to laryngospasm and laryngeal edema (Mirra; Spadavecchia; Micieli, 2022).

In this context, well-planned procedures, together with effective and safe anesthetic protocols, are necessary to ensure successful interventions. Dissociative anesthetics, such as ketamine and

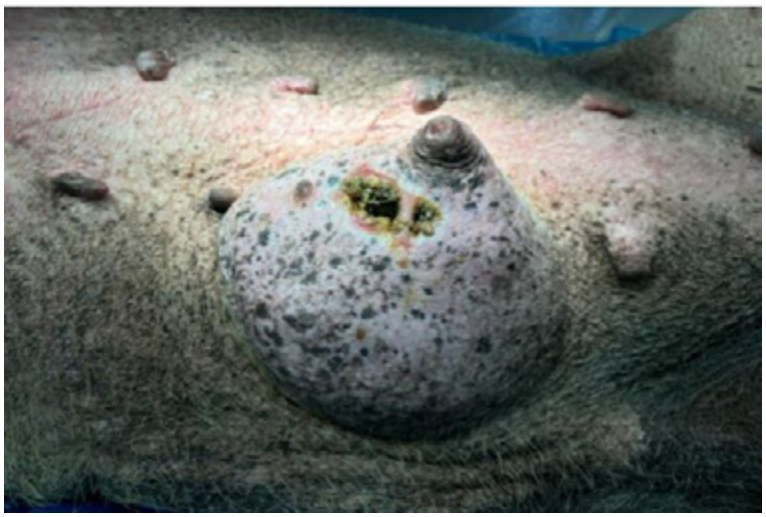
tiletamine, are commonly used for chemical restraint and provide rapid immobilization, with few cardiopulmonary adverse effects (De Monte *et al.*, 2015). To prevent muscle rigidity and promote a better sedative effect, these drugs are generally combined with α2-adrenergic agonists and benzodiazepines (Heinonen *et al.*, 2009).

Although several studies address technical aspects and research models involving humans, there is a scarcity of studies on anesthetic protocols in domestic pigs outside experimental settings. Therefore, the present case report aims to contribute to the veterinary literature by describing the anesthetic management of a female pig undergoing regional mastectomy for the removal of squamous cell carcinoma of the mammary gland.

Case description

A 13-year-old female Vietnamese miniature pig weighing 94 kg was admitted to the veterinary clinic of the Pontifical Catholic University of Campinas on October 9, 2024, with a history of progressive growth of a nodule located in the right abdominal region. Physical examination revealed a single, ulcerated, and adhered nodule measuring approximately 10 cm in diameter, with myiasis in the right caudal abdominal mammary gland (Figure 1). Surgical removal was therefore indicated for subsequent histopathological diagnosis.

Figure 1 – Neoplasm in the right abdominal mammary gland



T Source: Ferruccio *et al.* (2024). Photograph authorized by the owners.

Clinical and laboratory examinations were performed for additional and preoperative assessment. Blood was collected by puncture of the external jugular vein for complete blood count and serum biochemistry analysis. The patient was subjected to a 12-hour food fast and a 2-hour water fast before the surgical procedure. In the preparation room, the patient was bathed to remove hair and dirt, with the aim of minimizing the risk of surgical infection.

As preanesthetic medication, xylazine was administered at a dose of 0.7 mg/kg intramuscularly (IM) in the pelvic limb, between the gluteal, semitendinosus, and semimembranosus muscles, with the patient already in the preparation room. After 10 minutes, local antisepsis was performed, and venous access was established through the right auricular vein. Following venipuncture, anesthesia was induced with ketamine at 2 mg/kg combined with midazolam at 0.1 mg/kg, administered intravenously (IV), with the aim of inducing lateral recumbency and facilitating the animal's transfer to the surgical table.

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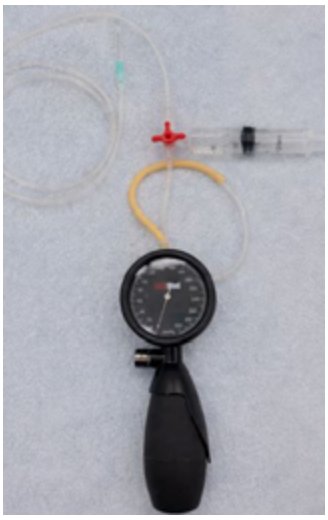
To initiate general anesthesia, following preoxygenation, fentanyl at 3 µg/kg and lidocaine at 0.5 mg/kg were administered IV, followed by propofol at 1 mg/kg through the same route. Once loss of the palpebral reflex, jaw relaxation, and motor desensitization were observed, the patient was positioned in dorsal recumbency and orotracheally intubated using a straight-blade laryngoscope and a 12-mm-diameter endotracheal tube. The patient was maintained under total intravenous anesthesia (TIVA) with a continuous propofol infusion at variable rates according to the anesthetic plane (0.05–0.1 mg/kg/min), combined with fentanyl at 3 µg/kg/h, ketamine at 0.2 mg/kg/h, and dexmedetomidine at 0.3 µg/kg/h.

The patient was maintained under spontaneous ventilation, and oxygen supplementation was provided throughout the surgical procedure using a circle breathing system with a continuous flow of 4 L/min. Maintenance fluid therapy with lactated Ringer's solution was administered at a rate of 5 mL/kg/h. For multimodal analgesia, a locoregional infiltrative block was performed with lidocaine at 4 mg/kg, followed by a splash block after complete removal of the mammary glands, using the same drug at the same dose, for a total dose of 8 mg/kg. Due to the extent of the nodule, removal of the adjacent mammary glands was necessary, resulting in the excision of a total of four mammary glands from the animal. Although longer-acting local anesthetics could have provided more prolonged postoperative analgesia, lidocaine was selected because no other agent was available at the time of the procedure.

Physiological parameters were monitored and recorded on an anesthetic record every 10 minutes until the end of the procedure. Heart rate (HR) and cardiac rhythm were assessed by electrocardiography using a base-apex lead. Initially, blood pressure was measured noninvasively using the oscillometric method. Subsequently, the metatarsal artery was cannulated, allowing mean arterial pressure (MAP) to be obtained using an invasive system (Figure 2). In this system, the arterial catheter was connected to a circuit filled with heparinized solution and coupled to an aneroid manometer, with the air column positioned at heart level, without integration into the multiparameter monitor.

Figure 2 – Circuit for invasive measurement of mean arterial pressure



T Source: Ferruccio *et al.* (2024).

Peripheral oxygen saturation (SpO_2) was measured using a sensor attached to the animal's tongue; temperature T (°C) was measured with a thermometer inserted into the nasal cavity; and end-tidal carbon dioxide concentration ($ETCO_2$) was measured using a sidestream capnograph, with the extension tube connected between the endotracheal probe and the circle breathing system, as shown in Figure 3.

Figure 3 – Left: positioning of the patient on the surgical table in dorsal recumbency, with the anesthesia monitoring equipment attached. Right: data obtained using the multiparameter monitor

T Source: Ferruccio *et al.* (2024). Photograph authorized by the owners.

The parameters recorded throughout the anesthetic procedure are presented in Table 1. These parameters were measured at baseline, immediately before administration of the preanesthetic medication, and every 10 minutes throughout the surgical procedure.

Table 1 – Physiological parameters recorded during 110 minutes of general anesthesia in a pig undergoing removal of a mammary chain neoplasm

	Tempo (minutos)											
Parâmetros	**0 (basal)**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**
FC (bpm)	120	80	83	78	80	80	84	75	75	75	70	73
PAM (mmHg)	-	85	76	90	92	93	96	85	94	93	90	94
***f* (rpm)**	30	13	10	6	5	6	5	6	5	5	7	7
SpO_2 (%)	-	98	96	96	96	99	99	99	99	98	99	99
$ETCO_2$ (mmHg)	-	34	35	35	35	35	33	35	33	32	32	30
T (°C)	38,0	38,1	37,9	37,9	37,9	37,9	38,0	38,0	37,9	37,9	37,8	37,7

T Note: HR – heart rate; MAP – mean arterial pressure; *f* – respiratory rate; SpO_2 – peripheral oxygen saturation; $ETCO_2$ – end-tidal carbon dioxide; T – temperature; bpm – beats per minute; rpm – respirations per minute.

T Source: Ferruccio *et al.* (2024).

As postoperative medication, the patient was administered 0.2 mg/kg of methadone, 0.1 mg/kg of meloxicam, and 15 mg/kg of dipyrone. As surgical prophylaxis, Borgal® (sulfadoxine + trimethoprim) was administered intramuscularly at a dose of 30 mg/kg of sulfadoxine. The patient remained hospitalized at the institution's veterinary hospital for 15 days, until suture removal. Continuous monitoring, surgical wound cleansing, and administration of the necessary medications were the responsibility of the residents in charge of the large-animal service. The sample obtained through excisional biopsy was submitted for histopathological evaluation, which established the definitive diagnosis of squamous cell carcinoma of the mammary gland.

Discussion

In accordance with the sedation protocols most frequently described in the literature for pigs (Heinonen *et al.*, 2009), preanesthetic medication consisted of a combination of an α2-adrenergic agonist, ketamine, and a benzodiazepine. Initially, the intramuscular administration of xylazine alone at 0.7 mg/kg produced only mild sedation, allowing venipuncture to be performed. Unlike ruminants

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and other domestic species, pigs are less susceptible to the sedative effects of α2-adrenergic agonists; therefore, higher doses than the one used in this case (1–2 mg/kg), administered intravenously or intramuscularly in combination with other drugs, are recommended (Costea; Ene; Pavel, 2023).

Therefore, ketamine and midazolam were subsequently administered as a complementary combination via the intravenous route, and the patient achieved lateral recumbency. While ketamine doses commonly administered intramuscularly range from 10 to 30 mg/kg, intravenous administration allows the use of lower doses (2–4 mg/kg) and provides a shorter onset of action (Heinonen *et al.*, 2009; Malavasi, 2015).

Propofol is a widely used intravenous general anesthetic for anesthetic induction, providing adequate conditions for orotracheal intubation (Garofalo, 2019). In addition to its use during anesthetic induction, the drug was also administered by continuous infusion for maintenance until the end of the surgical procedure, providing adequate control of the anesthetic plane, safe anesthesia, and smooth recovery. The use of continuous propofol infusion in pigs has been positively described in the literature (Demestiha *et al.*, 2010; Lervik *et al.*, 2018), as it avoids the use of volatile anesthetic agents, such as halogenated agents, which may trigger malignant hyperthermia in genetically susceptible pigs, particularly in association with halothane (McInnes; McKeag, 2016).

However, as in other species, propofol may cause hypotension and respiratory depression (Lervik *et al.*, 2020). These adverse events were not observed in the present case, possibly because a lower infusion rate was used than that reported in the literature (Lervik *et al.*, 2018; Schöffmann *et al.*, 2009), namely 0.15 mg/kg/min. This was possible because of the administration of the additional analgesic infusions included in this multimodal protocol. This significant reduction in the requirement for general anesthetics was also beneficial during recovery, as it resulted in less drug accumulation in adipose tissue and faster recovery.

Regarding respiratory depression, no evident changes were observed, such as prolonged apnea, decreased peripheral oxygen saturation, or hypercapnia. However, mild to moderate respiratory alterations cannot be ruled out, as the monitoring protocol did not include tests for respiratory assessment, such as arterial blood gas analysis, which would have allowed evaluation of the partial pressures of oxygen (PaO_2) and carbon dioxide ($PaCO_2$) in arterial blood.

Despite the limited literature on the use of dexmedetomidine and fentanyl as continuous infusions, these drugs are used in anesthetic protocols for pigs to provide sedation, analgesia, muscle relaxation, and reduced requirements for general anesthetics. Lervik *et al.* (2018) compared the cardiovascular and analgesic effects of these drugs, both administered by continuous infusion in combination with ketamine as part of a TIVA protocol in pigs, resulting in good analgesia and cardiovascular stability. However, dexmedetomidine infusion rates reported in the literature range from 2 to 8 µg/kg/h (Lervik *et al.*, 2018, 2020), which are considerably higher than the rate used in the present case (0.3 µg/kg/h), probably due to the multimodal protocol adopted, which allowed for this significant reduction in dosage.

Another important aspect of anesthesia in large animals is that it is frequently performed in the field, outside a structured surgical environment, with limited or unavailable monitoring equipment. This reality significantly increases anesthetic risks (Portier; Ida, 2020), as the absence of cardiorespiratory and body temperature monitoring is directly associated with a higher incidence of complications and anesthetic mortality (Grubb *et al.*, 2020). In this context, the implementation of comprehensive monitoring, as adopted in the present case, was essential for anticipating complications, enabling early interventions, and ensuring safe anesthetic recovery.

In addition, anesthetic recovery represents a critical stage, particularly in large animals undergoing invasive and prolonged surgical procedures (Portier; Ida, 2020). A recent study (Camlic *et al.*, 2025) reinforces the importance of monitoring during the immediate postoperative period, reporting a high mortality rate in pigs within the first 24 hours after anesthesia. In the present case, prolonged hospitalization allowed intensive support during the immediate postoperative period,

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adequate analgesic management, and continuous monitoring of the patient's clinical progress until hospital discharge. The use of methadone postoperatively, based on pain scale assessment, contributed to stress reduction and promoted the patient's welfare. Its use in postoperative management in this species is poorly documented and requires further investigation.

Given the scarcity of reports in the literature on comprehensive anesthetic protocols and advanced monitoring in domestic pigs, particularly in non-experimental clinical and surgical settings, the present case report provides a relevant contribution to Veterinary Medicine. In addition, mammary neoplasms in domestic and production pigs are rarely reported (Newman; Rohrbach, 2012), making this case report even more significant.

Final considerations

The present case report demonstrated the feasibility of safely and effectively performing TIVA protocols in pigs through a well-planned anesthetic protocol, rigorous monitoring, and a multimodal analgesic approach. The combination of anesthetic techniques and postoperative care was essential for the patient's successful recovery. This case reinforces the importance of individualized anesthesia in domestic pigs and contributes to the limited literature on the use of TIVA in miniature pig breeds undergoing routine veterinary surgical procedures. &

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CRediT Author Statement

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- **Conflicts of interest**: The authors declare that they have no conflicts of interest related to the conduct or publication of this work.
- **Ethical approval**: The study was conducted in accordance with the ethical principles applicable to research. As this was a surgical case report involving diagnostic and therapeutic procedures performed as part of routine hospital care, submission to an Ethics Committee was not required. The animal's legal guardian was duly informed and consented to the procedures.
- **Data and materials availability**: The data supporting this study are fully described in the article itself. The bibliographic materials used are properly referenced and available in scientific databases. Additional information may be made available by the authors upon request.
- **Author contributions**: FERRUCCIO, C. A.: study conception, conduct of the anesthetic procedure, patient follow-up, data collection, manuscript drafting, and manuscript revision. GUIMARÃES, P. C.: anesthetic preceptorship and supervision, scientific guidance, and critical revision of the manuscript. SARRI, B. M.: participation in anesthetic management and perioperative follow-up of the patient. BACCARELLI, D. C.: supervision of the large animal anesthesiology and surgery department and case follow-up. SOBRAL, C. A.: participation in the clinical follow-up and management of the patient. SILVA, I. L.: participation in the clinical follow-up and management of the patient. RANGEL, M. S.: assistance with patient care and perioperative follow-up. TARELHO, A. B.: clinical follow-up and management of the patient. AIELO, J. B.: evaluation and interpretation of diagnostic imaging examinations. BARROS, M. A. de: clinical supervision and scientific guidance.

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