ISSN: 1220-3173; E-ISSN: 2457-7618

HYPERCAPNIA IN A PIG, SECONDARY TO A HUMAN ANAESTHESIA ERROR

HIPERCAPNIA LA PORC, SECUNDARĂ UNEI ERORI ANESTEZICE UMANE

Ruxandra COSTEA[1),*)], Ioana ENE[1)], Ruxandra PAVEL[1)]

ABSTRACT | REZUMAT

The objective of this study is to describe the circumstances of a case characterized by severe hypercapnia in a pig, during anaesthesia for a surgical research procedure- nerve reconstruction, highlighting the importance of familiarization with the anaesthesia machine and technique and also to demonstrate the need for continuing continuous monitoring during anaesthesia and the necessity of quick reactions for solving the possible complications. It is discussed the case of a pig that was subjected to general inhalation anaesthesia with orotracheal intubation, during which significant hypercapnia developed, due to a human error that occurred before anaesthesia, during the dismounting and emptying of the carbon dioxide absorber of the anaesthesia machine.

Keywords: swine, anaesthesia, hypercapnia, error

Obiectivul acestui studiu este de a descrie circumstanțele producerii unui caz caracterizat de hipercapnie severă la porc, în timpul anesteziei pentru o procedură chirurgicală experimentală - reconstrucție nervoasă, evidențiind importanța familiarizării cu aparatul și tehnica de anestezie și, de asemenea, demonstrând necesitatea monitorizării continue în timpul anesteziei și necesitatea unor reacții rapide pentru rezolvarea eventualelor complicații. Se discută cazul unui porc care a fost supus unei anestezii generale inhalatorii cu intubație orotraheală, în cursul căreia acesta a dezvoltat hipercapnie semnificativă, din cauza unei erori umane survenite anterior anesteziei, în timpul demontării și golirii recipientului destinat absorbantului de dioxid de carbon, al aparatului de anestezie.

Cuvinte cheie: porc, anestezie, hipercapnie, eroare

While most of the anaesthetic complications, during anaesthesia in pigs, are related to the high sensibility regarding stress factors during contention, some important complications may also occur: difficult vascular access and intubation, rapid installation of hypothermia, the occurrence of malignant hyperthermia while using gaseous anaesthetics, anaphylaxis, regurgitation and aspiration pneumonia (2). Hypercapnia during swine general anaesthesia, triggered by a human error during anaesthesia, is a rare condition that can be a life-threatening situation, requiring rapid stabilization measures.

MATERIALS AND METHODS

A 5-month-old, female Landrace pig (*Sus scrofa*), weighing 40 kg, required general anaesthesia for a research surgical procedure, involving nerve reconstruction. All the procedures were approved by the Faculty of Veterinary Medicine Ethics Committee.

Before the procedure, the subject was transported and accommodated in order to allow stress reduction prior to anaesthesia (7). Physical preanesthetic examination was performed in a low-stress environment and revealed pink and moist mucous membranes, a capillary refill time <2 seconds, heart rate of 96 beats per minute with 60- 100 beats per minute reference values (2), regular rhythm and no murmur, peripheral pulses synchronous with the heart rate, respiratory rate 18 breaths per minute, with 8 - 18 breaths per minute reference values (4). Access to water was not restricted, while feeding was stopped for 12 h before anaesthesia.

Anaesthesia - the protocol started with intramuscular premedication with a combination of xylazine 2 mg/kg (Xylazin Bio 2%, Bioveta, Czech Republic) and ketamine at 20 mg/kg (Ketamine 100 mg/ml, Richter Pharma AG, Austria) and induction of anaesthesia with intravenous (auricular vein) propofol 1.5 mg/kg Propofol 10mg/ml (Proposure, Axience, London, England), slowly until effect (1). The subject was intubated with a 5.5 mm diameter, cuffed endotracheal tube with the help of a long blade laryngoscope and a stylet. Anaesthesia was maintained with 1.5% isoflurane (Vetflurane, 1000 mg/g, Virbac, Carros Cedex, France) vaporized in 100% oxygen at 0.9 l/minute delivered through a circle breathing system of a Drager Fabius anaesthesia machine. In order to ensure a multimodal approach a continuous rate infusion of Ketamine 0.5 mg/kg/h (Ketamine 100 mg/ml, Richter Pharma AG, Austria) and Lidocaine 1.5 mg/kg/h (Xilina 10 mg/ml, Zentiva, Prague, Czech Republic), com-

1) University of Agronomic Sciences and Veterinary Medicine, Faculty of Veterinary Medicine, Bucharest, Romania
*) *Corresponding author: ruxandra.costea@fmvb.usamv.ro*

pleted the partial intravenous anaesthetic techniques (6), in order to minimize the dose-dependent cardiopulmonary effects of the inhalant drugs used during maintenance (3). Multiparameter monitoring (veterinary monitor COMEN C80-V) during anaesthesia included end-tidal carbon dioxide pressure (ETCO2) and capnography, pulse oximetry, electrocardiography, temperature, and indirect blood pressure measuring.

RESULTS AND DISCUSSIONS

The subject was breathing spontaneously from the beginning of the maintenance of anaesthesia until the end of the surgical procedure (55 minutes). Vital parameters remained within normal limits, except for the end-tidal $C0_2$ and the respiratory rate (tachypnoea) which started to increase slowly immediately after intubation, simultaneous with the presentation of an abnormal capnograph wave (Fig. 1). The end-tidal carbon dioxide pressure ($ETCO_2$) measured during the procedure continuously raised from 50 to 125 mmHg.

Fig. 1. The capnogram indicates rebreathing, hypercapnia

The origin of hypercapnia can be represented by a disfunction of CO_2 produced, reduced elimination as a result of impaired alveolar ventilation, or in some cases inspired by rebreathing or directly from the circuit (5). While mild hypercapnia ($ETCO_2$ 50 mmHg) can improve tissue oxygenation through improved tissue perfusion resulting from increased CO_2 and vasodilatation, severe hypercapnia with increased respiratory frequency cand lead to may lead to significant diaphragm muscle dysfunction/fatigue and hypercapnic respiratory acidosis (8). For a quick differential diagnosis, we excluded excessive CO_2 production as the prea-anaesthetic examination resulted in a healthy clinical result. The next step was to evaluate the ventilation, the minute volume, as well as any dead space. Since the patient spontaneously ventilated with the frequency and tidal volume corresponding to his species and weight, we quickly tried to exclude the dead space represented by the extension connector between the probe and the capnograph module (Fig. 2). We removed this extension and connected the module directly to the probe, the result of capnometry and capnography remaining unchanged - the same values, the same curve.

Fig. 2. The connector and the capnograph

A rebreathing situation was suspected in which the exhaled CO_2 was re-inspired and possibly related to an incompetent valve or soda lime depletion. Since the check of the anaesthesia machine before the procedure was performed by a different person than the one who performed the anaesthesia, the first actions involved the confrontation of the pre-anaesthesia files and actions, from which it emerged that the soda lime was changed before the procedure. The expiration date was checked, as well as the canister was visually inspected. No errors could be detected in this phase. It was decided after 12 minutes in which the CO_2 level was increasing, without having a logical explanation, to disconnect the patient and connect it to another anaesthesia machine and continue the checks. Immediately after connecting the patient to the new anaesthesia machine, the capnogram began to normalize and the level of CO_2 decreased gradually, and slowly (Fig. 3). At that moment we had the confirmation of the fact that the aetiology of hypercapnia was related to the equipment and not to the patient.

We start to check the first machine. The tightness of the absorber was checked and it was tight, there were no leaks, an aspect also confirmed by the leak tests performed before using the anaesthesia machine. When the absorber was opened, we noticed that the dust filter was placed upside down, an aspect that we could not visually detect when the device was operating with a connected patient (Fig. 4). Practically at the time of changing the soda lime, without respecting the manufacturer's instructions for use (see https://www.draeger.com/), the filter was put after filling the absorber, with the sieve facing outwards, in this way

the absorption of the CO_2 was blocked.

Fig. 3. The capnogram and the carbon dioxide level returning to normal values

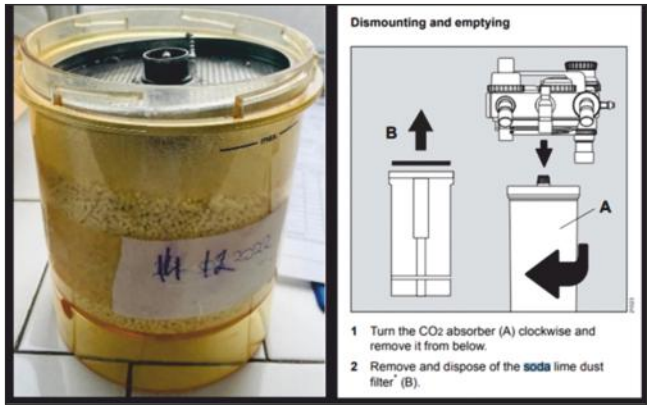

Fig. 4. Wrong assembly of the absorber, compared to the correct positioning (manufacturer's instructions)

CONCLUSIONS

This was a human error, difficult to detect when the machine was operating, with the patient connected to the circuit, which quickly determined the installation of hypercapnia during anaesthesia. Even if the monitoring of vital parameters did not show major variations with the exception of the CO_2 level, there was the suspicion of undiagnosed side effects, with an impact at the organic, tissue and cellular level. There are numerous studies in human medicine that show the limit between the therapeutic effect of mild hypercapnia and the demonstrated potential adverse effects for hypercapnia correlated with the duration and the level reached. The correct intervention facilitated the stabilization of the patient and the avoidance of an imminent anaesthetic incident.

REFERENCES

1. *Bîrtoiu I.A., Badea R., Sîrbu-Boeti M., Efrimescu C.,* (2008), Different anesthesia protocols used for experimental swine surgery. Lucrari Stiintifice-Universitatea de Stiinte Agricole a Banatului Timisoara, Medicina Veterinara, 41:526-529
2. *Costea R., Tudor R., Degan A., Gîrdan G.,* (2019), Anesthesia complications related to swine experimental invasive surgical procedures. Scientific Works, Series C, Veterinary Medicine, 65(1):2065-1295
3. *Duval J.D., Pang J.M., Boysen S.R., Caulkett N.A.*, (2018), Cardiopulmonary effects of a partial intravenous anesthesia technique for laboratory swine. J Am Assoc Lab Anim Sci, 57(4):376-381
4. *Gregg C., Siegle L., Clarke T.*, (2020), Monitoring Livestock Vital Signs. Virginia Cooperative Extension, Virginia Tech, Virginia State University, Available at: https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/APSC/apsc-169/APSC-169.pdf
5. *Kavanagh B.P., Laffey J.G.*, (2006), Hypercapnia: permissive and therapeutic. Minerva Anestesiologica, 72(6):567-576
6. *Lin H.,* (2015), Comparative anesthesia and analgesia of ruminants and swine, In: Kurt A. Grimm, Leigh A. Lamont, William J. Tranquilli, Stephen A. Greene, Sheilah A. Robertson editors, Veterinary Anesthesia and Analgesia, The Fifth Edition of Lumb and Jones, (Ed.) Wiley-Blackwell, Hoboken, New Jersey, USA, 743-753
7. *Staicu E., Mitranescu E., Oraseanu A., Tudor L., Furnaris F.*, (2008), Research on monitoring microclimate physical and chemical factors and their influence on the welfare of intensive swine rearing system. Lucrari Stiintifice-Universitatea de Stiinte Agricole a Banatului Timisoara, Medicina Veterinara, 41: 918-921
8. *Way M., Hill G. E.,* (2011), Intraoperative end-tidal carbon dioxide concentrations: what is the target ? Anesthesiology Research and Practice, 2011 (2011) :271539.