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USE OF SURFACTANTS IN CATTLE AND PIGS

USO DE SURFACTANTES EM BOVINOS E SUÍNOS

USO DE TENSOACTIVOS EN BOVINOS Y PORCINOS

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ABSTRACT

Many questions have been raised about the protein-surfactant interconnection. Surfactant-protein interconnections are very common in the field of veterinary medicine, animal husbandry, among others. Certainly, several aspects of this interconnection have been studied, such as the influence of the state of surfactant aggregation (monomer, premicellar

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aggregate, micelle and liposome) on the protein structure, the properties of the surfactant-protein system, the characterization of the interconnection sites on the protein surface, the identification of intermediate protein conformations, etc. The interconnection of different types of protein with the different species of surfactant can offer several information for the research of biochemical and biophysical systems, such as the structure-activity relationship of proteins as well as the mechanism of interaction between proteins and amphiphilic molecules. Its use for the treatment of respiratory and fetal diseases in cattle and pigs is very important for the well-being of herds, but little discussed when compared to the human medical literature. Thus, it is expected to contribute to the dissemination of this topic and increase its usability.

Keywords: Fetus. Lung. Protein.

RESUMO

Muitas questões têm sido levantadas sobre a interconexão proteína-surfactante. Interconexões surfactante-proteína são muito comuns na área da medicina veterinária, zootecnia, entre outras. Certamente, vários aspectos dessa interconexão têm sido estudados, como a influência do estado de agregação do surfactante (monômero, agregado pré-micelar, micela e lipossomo) na estrutura da proteína, as propriedades do sistema surfactante-proteína, a caracterização dos sítios de interconexão na superfície da proteína, a identificação de conformações proteicas intermediárias, etc. A interconexão de diferentes tipos de proteínas com diferentes espécies de surfactantes pode oferecer diversas informações para a pesquisa de sistemas bioquímicos e biofísicos, como a relação estrutura-atividade de proteínas, bem como o mecanismo de interação entre proteínas e moléculas anfifílicas. Seu uso no tratamento de doenças respiratórias e fetais em bovinos e suínos é de extrema importância para o bem-estar dos rebanhos, porém pouco discutido quando comparado à literatura médica humana. Assim, esperamos contribuir para a disseminação deste tema e aumentar sua usabilidade.

Palavras-chave: Feto. Pulmão. Proteína.

RESUMEN

Muchas preguntas han sido levantadas sobre una interconexión de proteína-surfactante. Las interconexiones surfactante-proteína son muy comunes en el área de la medicina veterinaria, zootecnia, entre otras. Ciertamente, varios aspectos de la interconexión han sido estudados, como la influencia del estado de agregación del surfactante (monômero, agregado pré-micelar, micela y lipossomo) en la estructura de la proteína, las propiedades del sistema surfactante-proteína, la caracterización de los sitios de interconexión de la superfície de las proteínas, la identificación de las conformaciones proteicas. intermediarias, etc. Seu uso no tratamento de doenças respiratórias and fetais em bovinos and suínos é de extrema importancia para o bien estar dos rebanhos, porém pouco discutido quando comparado con la literatura médica humana. Así mismo, esperamos contribuir para la difusión de este tema y aumentar su usabilidad.

Palabras clave: Feto. Pulmón. Proteína.

1 INTRODUCTION

In Brazil, there is a production chain of bovine and pork inputs that plays a relevant role in the country's economic development, being responsible for the food supply and generation of jobs and income for the population. Brazilian pig farming occupies a prominent position in the world agricultural scenario, with Brazil being the fourth largest producer and exporter of pork, behind only China, the European Union and the United States. This production chain is responsible for feeding millions of people and significantly moving the national economy. In addition to its economic weight, modern pig farming requires high standards of animal welfare, biosecurity and sustainability, placing the veterinarian in a strategic position to ensure the quality of products and the health of herds. The sector has undergone significant advances in recent decades, with emphasis on genetic improvement, optimization of feed conversion, professionalization of management and adoption of environmental technologies, such as the use of biodigesters for waste treatment. Such measures have allowed Brazil to stand out not only for its productivity, but also for its commitment to responsible practices in line with the demands of the global consumer market (Galvão et al., 2019; Paniaguá and Santos, 2021).

Among the inputs from cattle farming, milk is among the first six most important products of Brazilian agribusiness (Barbosa et al., 2009). Taking into account the representativeness of dairy cattle farming in our country, the concern with animal mortality rates becomes increasingly imperative. With regard to mortality in calves, respiratory distress syndrome (SAR) is of important relevance in the perinatal period (Eigenmann et al., 1984), however, there are no data on its incidence in this species in the literature. SAR, defined as progressive respiratory failure, is caused by inadequate surfactant production or function. The disease has already been described in premature newborns of the sheep, porcine, bovine and equine species (Vaala and House, 2006).

Pulmonary surfactant is a lipoprotein substance produced by type II pneumocytes that plays an essential role in the respiratory physiology of animals, especially during the neonatal period. Its main function is to reduce surface tension in the pulmonary alveoli, preventing their collapse at the end of expiration and ensuring the maintenance of pulmonary compliance and efficient gas exchange. In Veterinary Medicine, attention to the development and functionality of surfactant is fundamental, especially in premature neonates or in situations of acute respiratory distress, such as Hyaline Membrane Disease. Deficiency of this substance is directly associated with respiratory failure in neonates of various domestic species. Therefore, the early identification of its insufficiency allows for more precise therapeutic interventions, such as the administration of exogenous surfactants, which have been

investigated as a promising approach in the ventilatory support of critically ill patients. In addition to its clinical importance, knowledge about surfactant contributes to the training of veterinarians who are better able to deal with respiratory neonatal challenges, promoting better clinical outcomes and a higher survival rate (Silva et al., 2023; Storch et al., 2011).

The objective of this study is to evaluate the importance of the use of surfactants in cattle and pigs as a way to treat and prevent animal mortality.

2 METHODOLOGY

This study consisted of an integrative literature review with the objective of gathering, analyzing, and discussing the available evidence on the use of surfactants in cattle and pigs, with emphasis on their application in the treatment and prevention of neonatal respiratory disorders. The selection of sources was carried out between the months of [month] and [month] of 2025, using the PubMed, Scielo, ScienceDirect, Google Scholar and the CAPES Journal Portal.

The following descriptors were used in Portuguese and English, combined by Boolean operators: "pulmonary surfactant", "bovine neonates", "porcine neonates", "respiratory distress syndrome", "respiratory treatment", "pulmonary surfactant", "calves", "piglets", and "respiratory distress syndrome". Inclusion was limited to scientific articles published in the last 20 years (2005–2025), focusing on experimental studies, systematic reviews, and clinical studies involving farm animals.

The inclusion criteria included publications that directly addressed the composition, function, mechanisms of action, and clinical applicability of pulmonary surfactants in cattle and pigs. Duplicate studies, studies focused exclusively on human medicine, or studies without access to the full text were excluded.

After screening the titles and abstracts, the selected articles were submitted to critical reading and systematization of the information through a file, prioritizing methodological aspects, main findings and conclusions. To complement the theoretical foundation, recognized veterinary physiology and neonatology textbooks in the area were also consulted.

3 RESULTS AND DISCUSSION

Generally, lung maturation at birth coincides with fetal maturity, and is directly related to surfactant production (Eigenmann et al., 1984). The function of the surfactant is to reduce the surface tension at the air-liquid interface of the alveoli, preventing their collapse and facilitating the respiratory work of the newborn, in addition to avoiding pulmonary edema (Rebello et al., 1996).

In recent years, studies have been carried out to clarify the importance of surfactant in lung maturation and the efficacy of tests to determine the stage of lung development, but most of them have application to the human species (Gil et al., 2010). Research with this scope is scarce in Veterinary Medicine (Toquetti et al., 2009).

Most of the advances that have occurred in relation to veterinary neonatal care in recent years are related to respiratory function, since pulmonary functional capacity is essential for the adaptation and survival of the neonate, emphasizing that respiratory problems, including SAR, are the main causes of perinatal mortality in cattle and swine (Bleul, 2009).

Pulmonary surfactant is essential for adequate ventilation, since it reduces the surface tension of the alveoli. It consists of a mixture composed of approximately 80% phospholipids (mainly dipalmitoyl-phosphatidylcholine, phosphatidylglycerol and phosphatidylinositol), 10% proteins (Surfactant Proteins A, B, C, and D), and 10% neutral lipids (Lobato, 2011).

According to what has been mentioned above, the action of the surfactant occurs in the terminal portions of the respiratory tract, that is, in the alveoli, saccular structures covered with epithelial cells (type I pneumocytes) interposed by cuboid cells (type II pneumocytes) which, together with basement membrane 7 and the capillary endothelium, form the selective air-blood barrier of the lungs. Type II pneumocytes produce lamellar bodies (CL), which carry the surfactant inside and, once excited, unwind to take the form of tubular myelin, responsible for decreasing the surface tension of the alveoli (Klein et al., 2014).

Therefore, the absence of surfactant leads to alveolar collapse, with extravasation of serum proteins into the alveolus, which further inhibit the production and function of surfactant, damaging the epithelium responsible for its production and gas exchange. Consequently, a vicious circle is established that culminates in respiratory failure (Whitsett et al., 1999). Thus, it can be concluded that surfactant is able to effectively reduce alveolar surface tension and facilitate the work of breathing in the neonate, avoiding ARDS and helping to adapt to extrauterine life.

The aforementioned authors proposed that avoiding preterm birth is the main preventive measure to reduce the risks and sequelae of neonatal respiratory morbidity, a fact that became evident after the study by Toquetti et al. (2009), in which the authors determined in which gestational period the bovine fetus begins to present surfactant-producing cells. When working with animals from slaughterhouses, it was demonstrated that this production began in the seventh month of pregnancy, but that only full-term newborns had lungs in the terminal alveolar phase, indicating that even with the presence of type II pneumocytes in the seventh gestational month, the animal would need to go through the final stages of maturation

in the subsequent two intrauterine months, even to have the progression of the maturation of the other organic systems. Thus, animals that do not go through all the stages of maturation are predisposed to the development of SAR.

The risks of this disease are higher in premature calves, especially in those born before 260 or 270 days of gestation, depending on whether breed 9 has taurine or zebu origin, respectively (Feitosa and Benesi, 2014). Due to its characteristics, the SAR in calves appears to be similar to that found in the human newborn (Eigenmann et al., 1984).

By means of recycling, the exogenous surfactant administered endotracheally remains in the airways for a prolonged period, suffering a minimum of catabolism, remaining in the lung tissue during the acute phase of the disease (the first 48 to 72 hours), only ceasing to function properly if it is inactivated by the proteins present in the alveolar edema, which would determine the need to administer a new dose of exogenous surfactant (Miyoshi, 2001).

Treatment with exogenous surfactant does not interfere with the metabolic pathways of the endogenous surfactant, and there is no feedback inhibition of its production. The first response to surfactant treatment is a rapid and intense increase in oxygenation, which occurs a few minutes after administration, allowing for a rapid reduction in inspired oxygen concentrations. Improvement in pulmonary compliance occurs more slowly, allowing a progressive reduction in the inspiratory pressure used in order to maintain an adequate tidal volume. Increased alveolar recruitment results in increased maximal lung volume and greater stability in expiration.

In general, taking into account the metabolic cycle within the type II pneumocyte, particularly if the initial lung injury is avoided, it is not necessary to use more than one dose of surfactant, and it should be administered endotracheally, with subsequent ventilatory support from mechanical ventilation equipment. An alternative in the treatment, when there is a lack of surfactants, is intravenous ambroxol hydrochloride, at the rate of 3mg/kg every 12 hours, thus favoring the increase in the production of pulmonary surfactant, or even the administration of corticosteroids in order to accelerate lung maturity.

4 CONCLUSION

Surfactant is formed relatively late in fetal life. The use of exogenous surfactant seems quite promising, since therapy with this new substance has allowed a reduction in neonatal mortality rates among preterm newborns. Of course, the sooner the treatment is carried out, the better the results. However, the appropriate use of this new class of drugs implies knowledge of the pathophysiology of the conditions, the composition, function, and metabolism of the pulmonary surfactant. Studies with surfactants in Veterinary Medicine are

scarce, due to the high cost of this drug, making new research necessary to make its use in the neonatal routine viable.

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