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The influence of the duration of the expulsive stage of parturition on the occurrence of postpartum oxidative stress in sows with uncomplicated, spontaneous farrowings

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ABSTRACT

The aim of the study was to determine the influence of the duration of the expulsive stage of parturition on the occurrence of postpartum oxidative stress in sows with uncomplicated, spontaneous farrowings. Twenty-five pregnant gilts were divided into three groups on the basis of duration of the expulsive stage of farrowing: (I) duration of the expulsive stage was below 3 hours; (II) duration of the expulsive stage ranged from 3 to 6 hours; (III) duration of the expulsive stage was longer than 6 hours. Blood samples were collected at 24 to 48 hours before and 24 hours after parturition. As indicators of alterations in the redox state, we quantified the enzymatic activity of glutathione peroxidase (GSH-Px), superoxide dismutase (SOD), and catalase (CAT), as well as the blood levels of glutathione (GSH), thiobarbituric acid reactive substances (TBARS), and sulfhydryl groups (SH groups). In group III, it was found that erythrocyte activity of CAT (63.89 ± 6.70 vs. 53.18 ± 2.32 U/g Hb), as well as plasma GSH concentration (0.088 ± 0.020 vs. 0.045 ± 0.024 mmol/g protein) and SH groups content (5.045 ± 1.256 vs. 3.383 ± 0.430 μmol/g protein) decreased significantly ($P < 0.05$) at 24 hours after parturition, compared with their values during the last 48 hours before parturition. The concentration of TBARS increased not significantly, although markedly at 24 hours postpartum in group III (0.124 ± 0.014 vs. 0.153 ± 0.031 μmol/g protein). The results indicate that uncomplicated, spontaneous parturition can lead to the occurrence of oxidative stress during the early postparturient period in sows, the intensity of which is related to the duration of the expulsive stage.

1. Introduction

Oxidative stress results from increased production of reactive oxygen species (ROS) and/or a decrease in antioxidant defense. This may occur when ROS are produced faster than they can be safely neutralized by antioxidant mechanisms. An uncontrolled increase in ROS production leads to peroxidative damage of macromolecules, which, in turn, may lead to destruction of cell membranes, degradation of cell structures, lysis of cells, and tissue damage. An imbalance between production and neutralization of ROS may cause immune suppression and disturbances in the metabolism and physiology [1–3]. These conditions can contribute and/or lead to the onset of health disorders [1]. It is thought that oxidative stress is implicated in the etiology of several diseases of the postparturient period in animals [4,5].

The findings of numerous studies have shown that ROS overproduction occurs during parturition, which may lead to oxidative stress postpartum in both mother and neonate [6–10]. According to the data from human medicine, the degree of oxidative stress in women after natural delivery depends on the duration of the expulsive stage of parturition [11–14]. Higher levels of oxidative stress in both

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mother and fetus after normal vaginal parturitions than in the case after parturitions carried out using Cesarean section have been demonstrated in pregnant women, which confirms the significant influence of the parturition process on ROS overproduction [6,11].

In sows, the duration of the expulsive stage (second stage) of farrowing is variable and ranges from 30 minutes to 10 hours [15]. Previous studies have shown that the duration of farrowing affects the course of the post-parturient period in sows, and a shortening of the expulsive stage limits the occurrence of diseases in this period and positively influences piglet vitality and development [16,17]. However, the issue as to whether a longer expulsive stage increases the oxidative stress of parturient sows has not yet been clarified.

Oxidative stress can be monitored with several biomarkers, including antioxidative enzymes and nonenzymatic antioxidants, as well as end products or intermediates of peroxidative processes of macromolecules such as lipids and proteins, which can be assessed in plasma and/or erythrocytes [18]. The aim of the study was to determine the influence of the duration of the expulsive stage of parturition on the occurrence of postpartum oxidative stress in sows with uncomplicated, spontaneous farrowings.

2. Material and methods

2.1. Animals and blood sampling

The experiment was approved by the Local Ethic Committee appointed by the University of Life Sciences in Lublin and was performed in accordance with animal protection regulations (Animal Experimentation Act dated January 21, 2005).

The study was performed on 25 gilts of Polish Large-White and Large-White × Landrace sows. All the animals came from one closed-cycle production farm. Once the pregnancy was diagnosed, the gilts were kept in pigsties, six individuals per sty. The sows were moved from the gestation to the farrowing unit 8 to 10 days before the expected farrowing date and kept in individual farrowing pens. During pregnancy, sows were fed according to the changing demands for nutrients and energy. The feed was prepared in the farm's mixer and contained barley, oats, wheat barn, rape cake, soybean meal, mineral lick, and premix for pregnant sows. Between Day 3 prepartum and 3 days postpartum, all the animals were clinically daily examined, in order rule out early manifestations of any diseases. All gilts qualified for the study were clinically healthy, the farrowings occurred spontaneously at 114 to 116 days of pregnancy, and no drug was administered during any stage of farrowing. Furthermore, no obstetrical assistance had been given. For each sow, the duration of the expulsive stage of farrowing (defined as the time between birth of the first piglet of a litter and birth of the last piglet of a litter) and litter size were recorded. To exclude any influence of litter size and fetal death, only gilts that had litters with 8 to 12 live born piglets in total were used in the study. The animals were divided into three groups on the basis of duration of the expulsive stage of farrowing. Group I consisted of eight gilts in which the duration of the expulsive stage was below 3 hours. Group II included nine gilts in which the duration of the expulsive stage ranged from 3 to 6 hours. Group III composed eight gilts in which the duration of the expulsive stage was longer than 6 hours.

Blood samples were obtained at 24 to 48 hours before parturition and 24 hours after parturition. Blood was collected from the vena cava cranialis into plastic tubes containing heparin. After red blood cell counting and hemoglobin determination, blood samples were centrifuged and plasma was obtained. Hemolysates were prepared from red blood cells remaining after plasma collection. After three times washing of erythrocytes with 0.9% NaCl solution, cold distilled water was added and then the whole sample was centrifuged at 3000 × g for 10 minutes in order to remove erythrocyte membranes. Plasma and hemolysates were frozen immediately after collection and stored at −76 °C until analysis.

2.2. Laboratory analysis

All assays described below were run in duplicate in the laboratory of the Department of Animal Biochemistry and Physiology of the Faculty of Veterinary Medicine in Lublin.

2.2.1. Antioxidative status

As antioxidants, the activity of antioxidative enzymes (glutathione peroxidase (GSH-Px), superoxide dismutase (SOD), and catalase (CAT)) in erythrocytes and the concentration of glutathione (GSH) in plasma were determined.

The activity of GSH-Px was determined by the spectrophotometric method described by Paglia and Valentine [19]. The method was based on the changes in absorbance resulting from the conversion of NADPH into NADP. The absorbance was measured at 340 nm (Ultrospec 2000, Pharmacia, Uppsala, Sweden). Enzyme activity was expressed in units per gram hemoglobin (U/g Hb). Intraassay 6.1% (n = 10) and interassay 7.5% (n = 10) coefficients of variation were established.

The activity of SOD was measured spectrophotometrically at 340 nm (Ultrospec 2000, Pharmacia) according to the method of Sun and Zigman [20]. The method was based on the inhibition of spontaneous adrenaline auto-oxidation by SOD in basic conditions. Enzyme activity was expressed in SOD units per gram hemoglobin (U/g Hb). Intraassay 6.5% (n = 10) and interassay 7.4% (n = 10) coefficients of variation were established.

The activity of CAT was determined spectrophotometrically at 480 nm (Ultrospec 2000, Pharmacia) according to the procedure described by Cohen et al. [21]. The method was based on the reactions between H_2O_2 and $KMnO_4$. Enzyme activity was expressed in units per gram hemoglobin (U/g Hb). Intraassay 7.1% (n = 10) and interassay 7.6% (n = 10) coefficients of variation were established.

The concentration of GSH in blood plasma was determined using an assay kit (glutathione assay kit, Cayman Chemical Company, Ann Arbor, USA). The method is based on the reaction of sulfhydryl groups of glutathione with DTNB (5,5′-dithiobis-2-nitrobenzoic acid) and the synthesis of yellow TNB (5-thio-2-nitrobenzoate anion). The amount of TNB correlates positively with the concentration of glutathione in the sample. The absorbance was