Some observations on cardiac failure in sows

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Abstract

Data pertaining to factors associated with cardiac failure were collected as part of a study on sow mortality in which cardiac failure was the major cause of death. A total of 116 sows from 24 herds was used and divided into two groups: group 1 comprised sows dead of cardiac failure (n = 43), and group 2, sows dead of other causes (n = 73). Individual sow records, clinical history, backfat thickness, body weight, heart weight, selenium content in liver, and urea concentration in aqueous humor were obtained for each sow. Results from the groups were compared using Student's *t*-test. Maximum and minimum outside daily temperatures were obtained for the study period. A stressful or demanding event for the cardiovascular system of sows was identified in 84% of the cases of cardiac failure: nearly two-thirds of the cases occurred during the peripartum period, and other stressful events included heat, fighting, mating, and transport. More than 40% of the cardiac failures occurred during the months of July and August. Sows dead of cardiac failure were heavier and fatter than sows dead of other causes. The former group also had a significantly smaller heart weight to body weight ratio; this difference was attributed to a greater body weight since the heart weights were similar in the two groups. The hepatic selenium contents and urea concentrations in aqueous humor were not significantly different between the two groups.

Résumé

Quelques observations sur les défaillances cardiaques chez les truies

Dans le cadre d'une étude prospective des causes de mortalité chez les truies, des données ont été recueillies sur les facteurs de risque associés à une défaillance cardiaque, cause principale de mortalité dans les troupeaux étudiés. Un total de 116 truies provenant de 24 troupeaux ont été utilisées et divisées en deux groupes; le premier groupe comportait les truies mortes de défaillance cardiaque (n = 43) et le deuxième, les truies mortes d'autres causes (n = 73). Le dossier individuel, l'histoire clinique, l'épaisseur du gras dorsal, le poids vif, le poids cardiaque, la concentration hépatique de sélénium et la concentration en urée de l'humeur aqueuse ont été obtenues pour chaque truie. Un événement stressant ou exigeant pour le système cardiovasculaire a pu être identifié dans 84 % des cas de défaillance cardiaque. Près des deux tiers de ces cas sont survenus durant la période péripartum, les autres événements stressants étant une température ambiante élevée, les batailles, les saillies ou un transport. Plus de 40 % des défaillances cardiaques sont survenues durant les mois de juillet et août. Les truies mortes de défaillance cardiaque étaient significativement plus lourdes et plus grasses que les truies du groupe 2. Le rapport du poids cardiaque sur le poids vif était aussi plus petit pour le groupe 1; cette différence a été attribuée à un poids vif plus élevé, étant donné que le poids cardiaque était similaire entre les deux groupes de truies. Les concentrations de sélénium dans le foie et l'urée dans l'humeur aqueuse n'étaient pas significativement différentes dans les deux groupes. Les auteurs mettent en relation les facteurs de risque identifiés et les particularités anatomo-physiologiques du système cardiovasculaire propres à l'espèce porcine.
(Traduit par Dr Thérèse Lanthier)

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Introduction

Losses in sow herds can be very serious, with annual death rates of up to 14% (1,2). Cardiac failure has been reported to be one of the three main causes of death in sows (1,3-5), and has accounted for up to 25% of the mortalities studied. A recent investigation by Chagnon *et al* (6) on the causes of death in sows showed that cardiac failure was the principal cause of death (31%), followed by torsions and accidents involving abdominal organs (15%), and by the cystitis-pyelonephritis complex (8%). We present herein additional data, obtained from the previously mentioned study, and pertaining specifically to risk factors associated with cardiac failure in sows housed in total confinement. Relationships between the factors identified and the anatomical and physiological peculiarities of the cardiovascular system of pigs are also discussed.

Materials and methods

Data were obtained during a one-year study of 24 swine breeding herds in Quebec on causes of sow mortality. Criteria used for the selection of these herds have been described previously (6). Each participant was asked to submit, to the diagnostic laboratory, every dead or moribund sow or mated gilt for 12 consecutive months. Detailed and standardized necropsies were performed on all submitted sows, even when the cause of death was obvious. Individual sow records and clinical history were used to investigate factors associated with sow mortality. Maximum and minimum outside daily temperatures were obtained from the local meteorological station of the provincial Ministry of Environment for the study period.

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Body condition was qualitatively evaluated using a body score of 0–5. Backfat thickness was measured on the dorsal midline at the fifth lumbar vertebra. Sows were weighed (±2 kg) and, for each pregnant sow, the fetuses or piglets were weighed (±0.2 kg) to determine the corrected body weight (sow weight minus litter weight). During necropsy, the heart was examined in a uniform manner, first by removing the pericardium and by sectioning the great vessels at the base of the heart. Cardiac chambers were exposed and washed; the heart was then weighed (±0.1 g).

Microscopic examinations were conducted on tissues collected from every sow. Samples of tissues collected included: mammary gland, skeletal muscles (longissimus dorsi, semitendinosus), brain, pituitary gland, thyroid gland, heart, lung, stomach, small and large intestine, pancreas, liver, spleen, kidney, adrenal gland, urinary bladder, uterus, and lymph nodes. These tissues were fixed in 10% neutral buffered formalin and processed for paraffin tissue sections according to conventional methods. Sections were stained with hematoxylin, phloxin, and saffron (HPS); special stains were carried out if necessary.

Additional tissue samples from each necropsied sow were collected for bacterial isolation. These specimens were cultured on blood and MacConkey's agar plates which were incubated aerobically at 37°C. Anaerobic incubation was performed if considered appropriate. Samples of liver from each sow were collected and stored at −20°C until analyzed for their selenium content using the neutron activation technique (7). A 5 g sample was first irradiated for ten seconds in the neutron flux (10^{12} neutrons/cm^2/s) of the slowpoke reactor. The selenium radioisotopes were then counted for 20 seconds with the gamma-ray detector (7). Values were expressed on a wet weight basis (μg/g). Methodology used for urea analysis of the aqueous humor has been described previously (6).

Among the 137 sows that died during the year, 21 were not submitted and, therefore, relevant data for these sows were not available for this study. Consequently, a total of 116 sows or gilts was used and divided into two groups. Group 1 comprised sows that had died of cardiac failure (n = 43), and group 2, those that had died of other causes (n = 73). The former diagnosis was made when lesions indicative of cardiac failure were observed. These lesions included transudate in the pericardial, thoracic, and abdominal cavities, dilation of cardiac chambers, pulmonary edema, and passive congestion of lung, liver, kidney, and spleen. Furthermore, to attribute a mortality to cardiac failure, other causes of death had to be carefully excluded.

A diagnosis of cardiac failure is difficult to establish because the lesions are not pathognomonic and can be observed as terminal events occurring in association with other disease processes. Although a diagnosis of cardiac failure cannot be definitively proven using current diagnostic procedures available, we believe that the cases referred to in this study were consistent with cardiac failure by the lesions observed and the careful exclusion of other causes of death. Therefore, these cases were considered to be cardiac failure, and this terminology will be used throughout the text. Data were entered into computer files, verified, and analyzed with the Statistical Analysis System (SAS Institute Inc., Cary, North Carolina, USA). Data from both groups of sows were compared using Student's *t*-test.

Results

Cardiac failure was the major cause of death in the study, and accounted for the loss of 43 sows and gilts. From the clinical history and the postmortem findings, it was determined that most of these cases were acute. When clinical signs were observed prior to death of these sows, they were generally limited to a short period of anorexia and dyspnea. Some of the same animals also had hyperthermia and lethargy.

The mean parity of females dead of cardiac failure (group 1) was 4.1 ± 0.4 (SEM) compared to 4.2 ± 0.3 (SEM) for those dead of other causes (group 2). Nearly 42% of the sows in group 1 and 23% of those in group 2 died during the months of July and August. The average outside temperatures in July and August were 22.3°C and 20.6°C, respectively. Eleven of the 18 cases of cardiac failure (61%) diagnosed in these two months occurred on days when the maximum outside temperature reached 32°C or more, compared to three of 18 (17%) for other causes of death.

Data obtained from the history and individual sow records revealed that there was often a stressful event that seemed to have triggered the cardiac failure. Such stressful or demanding events for the cardiovascular system of sows were identified in 84% of the cases of cardiac failure (Table 1). Nearly two-thirds of these deaths occurred during the peripartum period, which was defined as the period from three days before the predicted farrowing date until three days after farrowing, inclusive. Other stressful factors included heat, fighting, mating, and transport. Seven deaths from cardiac failure could not be related to any specific event.

Sows dead of cardiac failure were significantly heavier and fatter than sows dead of other causes. The ratio of their heart weight to body weight was significantly smaller; this was associated with greater body weight, since heart weights were similar in the two groups (Table 2). Body weight and backfat thickness of sows dead of cardiac failure were further compared to a subgroup of sows that died rapidly from acute conditions, to verify whether the difference noted between sows of groups 1 and 2 could have been attributed to the loss of weight in some affected females from group 2. Sows dead of cardiac failure (n = 43) were also heavier and fatter, even when controlled for parity, than the selected subgroup of sows (n = 36). The latter subgroup comprised females that died from torsions and accidents involving abdominal organs, uterine prolapses, and some miscellaneous acute conditions.

The urea concentration in aqueous humor for sows dead of cardiac failure was 9.2 ± 1.5 mmol/L (SEM) compared to 10.4 ± 1.5 for sows dead of other causes except cystitis-pyelonephritis, a difference that was not statistically significant ($p > 0.05$). There was also no significant difference between the mean hepatic sele-

Table 1. Stressful events associated with cardiac failure in sows

Stressful event	Number of sows	Percentage
Parturition	20	47
Parturition and heat stress	7	16
Heat stress	4	9
Mating	2	5
Fighting	2	5
Transport	1	2
None identified	7	16
Total	43	100

Table 2. Comparative anatomical data (mean ± SEM) of sows dead of cardiac failure (group 1) and those dead of other causes (group 2)

Anatomical data	Cardiac failure	Other causes
Backfat (mm)	29.1 ± 2.0	23.7 ± 1.5[a]
Body score (0–5)	3.0 ± 0.1	2.7 ± 0.1[a]
Body weight (BW) (kg)	207 ± 7	177 ± 5[a]
Corrected body weight (cBW)[b] (kg)	201 ± 7	174 ± 4[a]
Heart weight (HW) (g)	666.5 ± 23.0	626.0 ± 16.7
HW/BW (%)	0.33 ± 0.01	0.36 ± 0.01[a]
HW/cBW (%)	0.34 ± 0.01	0.37 ± 0.01[a]

[a]Significant difference at a p value < 0.05
[b]Corrected body weight in pregnant females = sow weight minus litter weight

nium values of sows from group 1 (0.84 ± 0.05 μg/g) and group 2 (0.89 ± 0.05).

Discussion

In this study, cardiac failure was the main cause of death in sows. This condition is one of several causes of acute death in sows and should not be overdiagnosed. A definite diagnosis of cardiac failure is difficult to establish and has to rely on all current diagnostic procedures available. Therefore, it cannot be based solely on gross examination. Moreover, a fresh carcass with minimal autolytic changes is required.

Some of the predisposing factors for cardiac failure have to be regarded in light of the ways pigs often overreact to exogenous factors in the environment, and, probably more importantly, of their particularly delicate cardiovascular system. In fact, the porcine heart has many anatomical and physiological peculiarities, namely its relatively low volume and small weight, its abnormal systolic to diastolic ratio, and its exceptional myocardial sensitivity to oxygen deficiency. This precarious situation may easily lead to irreversible overload of the circulatory system and to the phenomenon of acute cardiac failure (8,9). The lack of exercise in sows raised in total confinement may also relate to cardiovascular fitness.

Thus, any factor that requires increased effort from the cardiovascular system in this species may be considered to predispose for cardiac failure. Results from the present study highlighted several factors: high ambient temperature, stressful events such as mating, fighting, and transport, parturition, and obesity. The majority of the cardiac failures appeared to have been triggered by a stressful or physiologically demanding situation. More than 60% of these deaths occurred during the peripartum period, a finding suggesting that parturition is a demanding event for the cardiovascular system of the sow. Many physiological changes influencing the functioning of the cardiovascular system occur at that time. As an example, the higher heart rate further increases the systolic to diastolic ratio that is already high in rested pigs compared to other species (10). When a high heart rate is maintained for a long period, the coronary blood flow may be impaired because of a longer systole, thus adding more strain on the cardiovascular system.

Heat stress was also found to be an important predisposing factor. Heat stress alone was considered to be the precipitating factor in the cardiac failure of four sows whereas, in seven other sows, there was a combined effect of thermal stress and the peripartum period. During parturition, activities related particularly to the expulsion of piglets increase the rate of energy expenditure (11). If the excess heat produced is not dissipated, deep-body temperature rises and heat stroke may result (12). High ambient temperature at the time of parturition exacerbates this effect by reducing heat flow to the environment (13,14). It has been reported that death from heat stroke in swine occurs only during the terminal stage of pregnancy in the hotter months (15). In another study, 25% of cases of heat stroke observed in sows occurred at parturition (12). The effect of heat stress on the cardiovascular system is complex and provokes, as a physiological response, peripheral vasodilation and increased cardiac output in order to increase cutaneous circulation as a means of inducing heat loss via radiation and convection (16,17). Pigs also have a limited capacity to sweat, a disadvantage for thermoregulation. When these compensatory mechanisms are overloaded, myocardial and circulatory insufficiency can occur (16,17). Some other predisposing factors for cardiac failure found in our study appeared to be related to management practices. One of the two sows that died during mating was left overnight with the boar, a practice that is not recommended. Two other sows died because they had been transferred to a new group of sows; fighting occurred as a hierarchy was established in the newly formed social group.

Sows dead of cardiac failure were heavier and fatter than sows dead of other causes. This difference could not be attributed to the age or parity of the sows, since the average parity was similar in the two groups. The ratio of their heart weight to body weight was smaller; this was associated with a greater body weight since the heart weights were again similar in both groups of sows. In humans, an overweight condition represents an important risk factor for cardiovascular disease and sudden death (18,19). Within a given animal species, it is well recognized that heavy individuals have a smaller relative heart weight compared to lighter individuals (20). In swine, the heart weight to body weight ratio decreases with the size of the animal (21), and, in adults, it is considered to be

among the smallest of domestic animals (22). This ratio is by far smaller than that of the less sedentary or more athletic species such as the dog, which has a ratio of about 0.8 (23). This small relative cardiac weight in pigs compared with other species may partially explain their predisposition to cardiac problems (8,24).

It is possible that some cases of cardiac failure were a manifestation of porcine stress syndrome (PSS). Necropsy findings in pigs that die from PSS are often nonspecific. Pale, soft, and watery musculature can, however, be observed in up to 70% of stress-susceptible pigs (25). Such muscular lesions were not found in any of the sows necropsied. The diagnosis of PSS is often based on clinical history. The rapid development of rigor mortis is also considered to be highly suggestive of PSS (25); this particular information was not reported by producers involved in our investigation. Several of the predisposing factors for PSS also appear to be risk factors for cardiac failure in sows. In some cases, PSS might be difficult to differentiate from a simple cardiac failure in a nonstress-susceptible animal. It is hoped that, in the near future, some of the new diagnostic procedures to identify stress-susceptible pigs (26,27) will be applied to postmortem investigations.

The urea concentrations in aqueous humor in sows dead of cardiac failure were not significantly different from those of sows dead of other causes with the exclusion of cystitis-pyelonephritis. Urea concentrations within ocular fluids have been shown to be highly correlated with serum values and to remain stable after death (28,29). Postmortem determination of intraocular urea concentration has also been demonstrated to be a reliable indicator of antemortem uremia (29,30). Sows dead of cardiac failure had no evidence of prerenal uremia based on the postmortem analysis of ocular fluids. This could be explained by a) the fact that many of these sows died quite acutely of cardiac failure and that the rate at which serum urea equilibrates in ocular fluids is slow (31), and b) the small increased urea concentration in prerenal uremia compared with uremia of renal origin (32).

Cardiac failures in sows did not appear to be associated with selenium deficiency, since there was no significant difference in hepatic selenium values between the groups of sows. The vitamin E status, however, was not evaluated in this study.

In the last century, pigs have been intensively selected for fast growth and it seems that the size of the heart has not kept pace with the increase in body weight (33). On a practical basis, the peculiar and precarious cardiovascular system of our modern, sedentary pigs obviously cannot be improved in the short term. Preventive measures to alleviate losses due to cardiac failure in breeding herds must therefore focus on environmental factors and management practices. Particular attention should be paid to periparturient females in the farrowing house. Ventilation in these units appears to be critical, particularly during hot summer months. In some cases, it might be necessary to install portable fans near peripartum sows or to drip cool them with water when high ambient temperature is prevalent. In gestation units, sows should be fed properly without allowing them to put on excessive weight and fat. Farm managers also must realize that these animals should be handled in such a way as to alleviate any form of stress or overexertion.

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