Reduced Cardiac Functional Capacity as a Consequence of the Double-muscled Conformation Selection in the Belgian White and Blue Breed

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Introduction

In the field of meat production in Belgium, the interest in double-muscled cattle is increasing because of the exceptional commercial value of the animals produced by such a selection. However, double-muscled cattle have a lower aerobic metabolic capacity than do conventional cattle.[1] Several steps in the oxygen-transport pathway might be responsible for this limited maximal oxygen consumption. Among these, the cardiovascular system has been suspected as a potential critical step.[1,2] The present study was performed in order to test this hypothesis by direct hemodynamic measurements.

Material and Methods

The study was conducted in two parts. For the first part of the study, 41 Friesian calves, considered as conventional, and 19 Belgian White and Blue double-muscled calves were studied repeatedly during their growth. A total of 123 and 70 recordings were collected in the conventional and double-muscled group, respectively. In these calves, central venous (CVP), right ventricular (RVP), pulmonary arterial (PAP), pulmonary capillary wedge (PW) and systemic arterial (SAP) pressures were obtained by means of fluid filled catheters positioned under pressure monitoring, heart rate (HR) was calculated from the ECG tracings and cardiac output (CO) was measured using the thermodilution technique. Stroke volume (SV), cardiac and stroke indices (CI and SI, respectively), and pulmonary and systemic vascular resistance (PVR and SVR) were calculated from the measured parameters.

For the second part of the study, 41 and 55 sets of hemodynamic records were collected from a group of 6 conventional and 6 double-muscled calves, respectively. In these calves, CVP, PAP, PW, SAP, SV and CO were measured as in the first part of the study. Right ventricular pressure was recorded by means of a microtip catheter and the maximal value of its first derivative with respect to time (Max dP/dt) was calculated from the tracings obtained by means of a differentiator amplifier. Right ventricular end-diastolic and end-systolic volume (EDV and ESV, respectively) and ejection fraction (EF) were measured by means of the thermodilution technique and using Swan Ganz catheters equipped with a rapid response thermistor. In each group of calves, the mean right ventricular pressure-volume loop was constructed from EDV, ESV, peak systolic RVP, proto- and end-diastolic RVP, and diastolic PAP values. The systolic elastance slopes (Ees) was calculated from the peak systolic RVP/ESV ratio. Diastolic elastance slope (Eed) was calculated from the [end-diastolic RVP - proto-diastolic RVP] / [EDV - ESV] ratio.

Statistical Analysis

The results obtained in the 2 groups were compared using a random linear nested model including the effect of calf, breed, and body weight.

Results and Discussion

The results of the first part of the study demonstrated that global cardiac performance, as expressed in terms of CO, SV, CI or SI, is significantly lower in double-muscled than in conventional calves, suggesting that the global cardiac performance is significantly poorer in double-muscled calves.

In a heart of given volume, performance is governed by 4 determinants: heart rate, preload, afterload and contractility.[3,4] Heart rate, CVP, diastolic RVP and

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PAP, and PW were similar in the 2 groups of calves. Therefore, the diminished cardiac performance of the double-muscled calves appeared to be related neither to a relative bradycardia, nor to a reduced ventricular preload. The potential role of increased ventricular after load was not likely because of the similar PAP obtained in the 2 groups and the significantly lower SAP and significantly higher PVR and SVR obtained in the double-muscled calves. Myocardial contractility was not evaluated in this part of the study but it was suspected to play a role in the reduced cardiac global performance of double-muscled calves, as it was previously suspected from echocardiographic studies.[5]

The results of the second part of the study confirmed a significantly lower CO and SV in the double-muscled calves. On the other hand, right ventricular EDV and ESV as well as the diastolic portion of the mean pressure-volume loop were not significantly different in the 2 groups. Those results confirmed that the reduced cardiac performance of double-muscled calves is not due to a lowered ventricular preload and demonstrated that diastolic properties of their myocardium are similar to those of conventional calves. When expressed per kg body weight, however, right ventricular volumes were lower in the double-muscled than in the conventional calves. The volumetric capacity of the cardiac pump appears thus, in view of the metabolic demand, to be reduced in double-muscled calves. On the other hand, the right ventricular EF, Max dP/dt and Ees were significantly lower in double-muscled than in conventional calves, demonstrating that a reduced myocardial contractility is also partly responsible for the significantly lower cardiac function.

In conclusion, the selection of the double-muscled character in cattle appears to produce animals with a less effective cardiac pump than animals with conventional bodily conformation. On the other hand, this reduced cardiac functional capacity seems to be due to a reduced volumetric capacity and a lowered strength of contraction of the heart.

Summary

In this hemodynamic study (conducted in 2 parts), cardiac function has been compared in double-muscled calves and in calves with conventional conformation.

Simultaneous measurements of cardiac output, cardiovascular pressures and ventricular volumes showed that in the bovine species, the double-muscled conformation selection induces a significant reduction of the cardiac output and the stroke volume.

This reduction in global cardiac performance is not due to a lower heart rate, a lower ventricular preload or an higher after load, but was rather associated with a reduced myocardial contractility and a lower indexed volumetric capacity.

References

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