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Space allowance influences individually housed Holstein bull calf innate immune measures and standing behaviors after castration at 3 weeks of age

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ABSTRACT

Dairy calves in the Southwest regions of the United States are typically raised individually in wooden hutches with 1.23 m^2 of space. The objective of the study was to determine if increased space allowance in wooden hutches influences measures of innate immunity and behaviors of Holstein bull calves pre- and postcastration. Calves were randomly assigned at 4 d of age to conventional (CONV; 1.23 m^2 of space; n = 18), moderate (MOD; 1.85 m^2 space; n = 17), or maximized space allowance (MAX; 3.71 m^2 space; n = 19) in hutches. Calves were surgically castrated at 24 d of age. Peripheral whole blood samples were collected at −1, +1, +5, and +12 d of castration. Accelerometer loggers (n = 16 calves per treatment) were used from −3 to +5 d of castration to assess standing behaviors. All calves decreased total standing duration the day of castration versus precastration. Overall, MAX spent the most time in the stand position postcastration versus CONV and MOD. Within treatments, MOD and MAX had increased plasma cortisol 1 d postcastration versus precastration. A treatment × time tendency was observed for cortisol at 12 d postcastration; MAX had the least circulating cortisol. A treatment × time tendency for circulating haptoglobin (Hp) was observed and Hp was greatest among CONV 1 d pre- and 12 d postcastration. Compared with precastration, CONV had increased Hp at 1, 5, and 12 d, whereas MOD had increased Hp at 5 d, and Hp remained similar within MAX. A treatment × time tendency for tumor necrosis factor-α (TNF-α) from lipopolysaccharide-stimulated whole blood was observed; at 1 d postcastration, MOD had the most TNF-α, whereas MAX had the least. Within MAX, calves had increased TNF-α from precastration to 5 d postcastration. A treatment × time interaction was observed for whole blood bactericidal activity against *Escherichia coli* (WB anti-E). The CONV tended to have the greatest WB anti-E at d −1, but at d 1 and 5 postcastration, CONV had the least WB anti-E. Overall, MAX had less intensity of neutrophil oxidative burst versus CONV and MOD. The lower response of neutrophil oxidative burst and slower Hp secretion after castration is indicative that the wound site likely had less microbial exposure. The findings of this study suggest that calves housed with more space are potentially at less risk of too much inflammation after castration, which may likely be due to the effects of increased space on hide cleanliness and increased standing time.
Key words: bovine, inflammation, castration, behavior

INTRODUCTION

In 2011, California's 1.78 million milking cows produced more than 19% of the dairy calves in the United States (NASS, 2012). In California and much of the Southwest United States, wooden hutches are used to house calves up to approximately 90 d of age. Each hutch provides 1.23 m^2 of space allowance per calf and calves within one unit can make limited contact with each other (Love et al., 2016). Many producers choose to individually house calves for the first few weeks of life because it may reduce the risk of disease transmission, facilitate farm worker health assessment and treatment of calves, and eliminate competition for milk/milk replacer, grain, and water (NAHMS, 2007; Costa et al., 2016; Hulbert and Moisá, 2016; Love et al., 2016). The conventional wooden hutch (versus the plastic or fiberglass hutch) is likely favorable in the Southwest region because producers modify these hutches with slatted-flooring, thus providing calves a more sanitary, cooler floor surface than dirt or bedding, especially during the

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summer months (Mogensen et al., 1997; Hulbert and Moisá, 2016; Love et al., 2016).

In recent years, the value of neonatal dairy bull calves tripled and in 2012 almost 1 in 5 steaks consumed in the United States were from dairy breeds (Wardynski, 2012; Hulbert and Moisá, 2016). Thus, dairy beef is an important commodity for high-producing dairy states, especially after drought events reduced the number of cattle in the beef industry (Burciaga-Robles, 2015). Many dairy calves are sold to specialized calf raising operations, otherwise known as calf ranches (Schaefer, 2005). Many calf ranches use the above described wooden hutches as their primary housing and management system.

Calf ranchers have a narrow timeframe to perform castration among preweaned calves. The American Veterinary Medical Association (**AVMA**) recommends that castration take place before weaning (Coetzee et al., 2010; AVMA, 2014). Logically, younger animals are easier to handle and have less tissue to excise; therefore, the confounding effects from damaged tissue and stress from handling are potentially reduced (Molony et al., 1995; Fisher et al., 1996; Stafford and Mellor, 2005). There are also incentives within the beef and dairy industries to castrate before weaning; uncastrated dairy-breed calves are typically discounted when sold at stockyards and feedlots when they reach 120 d of age (Webster et al., 2013; Hulbert and Moisá, 2016). However, the timeframe for calf-managers to castrate is further narrowed because dairy calves are at the greatest risk for enteric disease from age 0 to 3 wk and step-down weaning is often initiated at 6 wk of age (NAHMS, 2007; Hulbert and Moisá, 2016). Therefore, calf ranchers will choose around 3 wk of age to castrate (Hulbert and Moisá, 2016). At this age, maternal antibodies are at their lowest if calves had successful passive transfer of maternal antibodies from colostrum and the calf is just starting to produce its own antibodies (Godden, 2008; Hulbert and Moisá, 2016).

There is a misconception that because older animals have a greater peak of cortisol release during castration, they are more stressed than young calves (Bretschneider, 2005; Stafford and Mellor, 2011). However, a lack of a cortisol response to painful procedures among calves may be a sign of an underdeveloped or dysfunctional hypothalamopituitary adrenal (**HPA**) axis (Mitra et al., 2009; Hulbert and Moisá, 2016). Calves are born with an innate inflammatory response (Kampen et al., 2006) that is dependent on its regulation from the HPA axis. Glucocorticoids reduce inflammation, whereas factors from damaged tissue directly and indirectly activate the HPA axis (Boutzios and Kaltsas, 2000; Mitra et al., 2009; Hulbert and Moisá, 2016).

Castration induces an inflammatory response that can be measured by monitoring acute phase proteins, circulating leukocyte populations, and neutrophil function (Pang et al., 2009, 2011; Ballou et al., 2013). For example, castrated Holstein calves had increased circulating leukocytes and haptoglobin (**Hp**), decreased neutrophil oxidative burst responses to *Escherichia coli*, and decreased tumor necrosis factor-α (**TNF-α**) secretion from whole blood stimulated with LPS (Ballou et al., 2013). The inflammatory response to surgical castration may also be influenced by calf behaviors, such as how much time the calf rests after castration. In general, castrated calves (without pain relief) spend significantly greater time standing postcastration versus precastration (White et al., 2008), and display increased behavioral indicators of discomfort, such as abnormal postures and increased activity (Robertson et al., 1994). Researchers (Repenning et al., 2013; Sutherland et al., 2013; Webster et al., 2013) added pain relief treatments for castrated calves and observed that these calves returned to maintenance behaviors sooner (grooming, resting, feeding, and drinking) than calves provided no pain relief. In addition, pain relief administered to calves in the Sutherland et al. (2013) study had less of a pro-inflammatory response, including reduced total circulating leukocytes and peripheral neutrophil:leukocyte ratios, than control calves. Ballou et al. (2013) also reported increased plasma Hp concentrations in calves provided pain relief versus calves not provided pain relief. Therefore, both the return-to-normal behavior activities and attenuated pro-inflammatory measures may be important indicators that calves experienced less pain or distress.

The conventional wooden hutch is criticized because calves have one-third to two-thirds less space than other individualized or group-based calf housing systems. Because of this criticism, producers may choose to modify the conventional wooden hutch to increase space allowance. After castration, it is expected that the calf will attempt to reduce discomfort by shifting from a lying to standing position, and shifting lying position between the right and left side (Robertson et al., 1994; White et al., 2008). The amount of space may influence whether or not the calf can enter a consummatory state (changing position). In short, less space may be less motivating for the calf to seek comfort. In addition, the larger hutch size may provide more sanitary surface areas to rest on after castration. The sanitation may reduce the amount of exposure to microbes; therefore, one may expect a lessened inflammatory response.

The objectives of this study were to determine if increased space allowance for calves housed in wooden hutches influences standing behaviors and inflamma-