The Effects of Stress on the Immunology of the Stocker Calf

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Introduction

Annual losses due to bovine respiratory disease have been estimated to be in excess of $500 million.[1] One of the primary components in the etiology of this disease process is stress. Actually stress is an environmental condition that results in strain on the animal causing alterations in its homeostasis[2]. Therefore it can be concluded that not all stress is detrimental, but adverse effects are seen only when a certain threshold is reached and the animal is no longer able to respond in an efficient manner. Many stressors contributing to bronchopneumonia have been identified and reported.[3] Of all these stressors, transportation seems to have the most detrimental effect on the animal. Serum cortisol concentrations are often used as a measure of stress. Trucking of calves resulted in a significant ($P<.05$) increase in cortisol levels while weaning produced only a small increase.[4] Another effect of transportation stress is excessive shrink. Studies conducted at this laboratory indicate that cattle that are transported shrink more than cattle that are deprived of feed and water for the same amount of time. Trucking and stress in general also have profound effects not only on the total numbers and percentages of white blood cells, but on their functional capabilities as well. It should be noted that the stresses of weaning, transportation, exposure to new or extreme environmental conditions, restructuring of social order, and exposure to pathogenic organisms are often encountered at about the same time so their effects may be additive.

Excessive Shrink Due to Stress:

Body shrink is important both economically as it results in a direct monetary loss and in the incidence of disease. In a survey at a southern plains feedlot involving 6012 animals, it was reported that for each one percent increase in shrink above a baseline of 4.7% morbidity increased 25.6%. On those same cattle for every one percent increase in shrink above a baseline of 5.4%, mortality increases 0.24%.[5] It should be noted that these figures are computed from pay weight to arrival weight. Research at this laboratory indicates that total weight loss from weaning to arrival at final destination in simulated or actual industry conditions ranges from 7 to 11% of body weight.[6] Other researchers have reported similar results.[7]

The loss of body weight is not only due to loss of gastrointestinal fill, but there is also some soft issue loss as well. Depending on the length of transit period, losses of feces and urine account for 60-70% of the actual body weight loss, the rest made up of soft issue loss and evaporative losses. Table 1 gives the composition of losses during a 48 hour period.[8] Trucked cattle were on the trailer for the entire period while the barn cattle were not transported but deprived of feed and water for the same period of time as transported cattle. Trucked cattle lost significantly more weight than cattle fasted but not transported, but the difference appears to be due to increased excretion of urine and feces. Therefore if one is going to attempt to decrease transit losses, he must attempt to decrease the rate of passage of ingesta and decrease urinary losses.

TABLE 1.

	Barn		Truck	
	kg	%	kg	%
Weight lost	15.5[a]		18.8[b]	
Feces	5.7	36.8	6.0	34.4
Urine	3.7[a]	24.4	6.2[b]	32.8
Total	9.4	61.2	12.2	67.2

[a, b] $P<.05$.

Effect of Stress on Cortisol Levels:

Cortisol concentrations are used as an indicator of degree of stress in animals. Serum cortisol concentrations increase in response to stress.[9] The magnitude of the increase in relation to the type of stress has been reviewed.[10] Crookshank et al. reported significantly elevated plasma cortisol concentrations in calves weaned and then transported for 12 hours.[4] Blecha et al. reported no significant increases in cortisol concentrations compared to controls. In fact, in pooled breed samples, trucked cattle had lower serum control concentrations than controls. It should be noted that baseline values for these cattle were higher than expected.[11] In studies performed at our laboratory it has been found that baseline cortisol levels are also elevated if blood is collected by jugular venapuncture in animals which are not conditioned to being handled.

Effect of Stress on Humoral Immunity:

Under certain conditions, glucocorticoids do have an effect on an animal's ability to respond to antigenic stimulation. Calves given either equine or porcine red blood cells one week prior to weaning, then the other antigen either the day of weaning or the day after weaning showed a significantly reduced antibody titer to the antigen given at or after the day of weaning. It was concluded that the stress of weaning along with high glucocorticoid concentrations are detrimental to antibody formation.[12] These data suggest that under certain circumstances the efficacy of vaccines used in processing cattle may be reduced if given to animals which are severely stressed.

Effect of Stress or Glucocorticoids or Lymphocyte Blastogenesis:

The lymphocyte blastogenesis or lymphocyte transformation assay in an *in vitro* test of the ability of lymphocytes to undergo mitosis. Basically, this assay is performed by isolating lymphocytes from a blood sample, adding a mitogen, usually phytohemagglutinin A (PHA), concanaval in A (Con A), or pokeweed mitogen (PWM), incubating and assaying for mitosis. PHA and Con A are generally considered to be T-lymphocyte specific while PWM, in man at least, will stimulate both T and B-lymphocytes.[9] When 10 yearling steers were given ACTH, serum cortisol levels increased significantly. Concurrently, lymphocyte blastogenesis in response to PHA and Con A was significantly reduced. The response to PWM was also reduced, but not significantly.[13] Blecha et al. reported that lymphocyte blastogenic responses to Con A were significantly lower in steers transported 700 km than steers which were not transported, while the response to PWM tended to be lower ($P<0.10$).[11] These data suggest that an increase in serum cortisol, whether it be due to stress or the administration of ACTH, reduces the ability of the lymphocyte to proliferate resulting in impaired cell mediated immunity.

Effect of Glucocorticoids on Neutrophil Function:

The value of the neutrophil in the immune response depends on its phagocytic capabilities. In order for a neutrophil to exert its bacteriocidal properties, phagocytosis must occur. It has been shown that a neutrophilia results due to increased serum cortisol levels.[13] [14] The increase in neutrophil numbers appears to be due to a decrease in the marginated pool. One would think with the increased number of neutrophils, the immune system would be enhanced due to glucocorticoids, however the functional capabilities of the neutrophil are reduced due to increased serum cortisol. The assays used to evaluate neutrophil function have been described.[15] The degree of impairment of neutrophil function appears to be related to serum cortisol levels. In a trial where steers were given 200 IU ACTH IM for 3 days, random migration under agarose was enhanced, and iodination reaction, which is a screening test to detect neutrophil dysfunction, was significantly reduced. There was no effect on the ingestion of *Staphylococcus aureus,* nitroblue tetrazolium reduction, or antibody-dependent cell-mediated cytotoxicity.[13] In another study, a single pharmacological dose of dexamethasone also caused an enhancement of random migration, and an impairment of the ingestion of bacteria, the oxidative metabolism, the myeloperoxidase-hydrogen peroxide-halide antibacterial system, and antibody-dependent cell-mediated cytotoxicity.[16]

The Effects of Assembly and Transit on Metabolic and Hematological Profiles:

The remainder of this manuscript will briefly summarize the results of a trial conducted at this location to evaluate the effect of weaning, assembly and transport of calves under conditions similar to actual industry channels. It is an attempt to evaluate the effects of the stressors involved in these events without confounding the results with disease, different farms of origin, or differences in previous management.

The calves were weaned from their dams, assembled at 72 h., then transported for 21 h. Blood samples were obtained pre- and post-weaning and pre- and post-transit. As was expected, the calves mean body weight decreased significantly ($P>0.05$) during weaning and transit. The net body weight loss was 8.1% of weaning weight.

TABLE 2. [17] TP, UN and GLU values during weaning and transit.

	TP g/dl				UN mg/dl				GLU mg/dl			
	Weaning		Transit		Weaning		Transit		Weaning		Transit	
Genotype	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
AHL[a]	6.40	6.83	6.64	6.75	2.77	10.86	4.31	10.27	89	97	81	108
AHS[b]	6.50	6.94	6.54	6.65	4.10	12.73	5.94	13.43	75	98	71	95
AB [c]	6.96	7.33	7.07	7.02	5.15	12.80	5.22	12.83	116	112	89	127
HB [d]	6.86	7.25	6.90	6.92	6.61	13.79	6.58	13.22	111	112	81	112

a. Large frame angus x hereford.
b. Small frame angus x hereford.
c. Angus x brahman.
d. Hereford x brahman.

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Serum concentrations of total protein (TP), urea nitrogen (UN), and glucose (GLU) were used to monitor metabolic responses to weaning and transit. The actual values are reported in Table 2. Weaning significantly increased the mean TP and UN levels, while transit resulted in significantly increased UN and GLU levels. The increase in TP values is probably due to dehydration and hemoconcentration. The increases in UN and GLU probably reflect a change in metabolism due to feed deprivation. The dramatically increased UN values suggest an increased rate of tissue catabolism while high GLU values are indicative of a shift to gluconeogenesis.

Whole blood was collected to determine the effects of weaning, assembly and transit or hematological parameters. Assays were done for concentrations of total leukocytes (WBC), total mononuclear cells (TMONO) which included monocytes and lymphocytes, mature neutrophils (NEUTRO) and hemoglobin (Hb). The results are summarized in Table 3. Weaning decreased TMONO and increased Hb. while transit resulted in a significant leukocytosis, neutrophilia and a decrease in Hb. The transit values are similar to those reported by Blecha.[11] The general pattern of the changes are similar to those detailed in the classic stress response. It should be noted that the leukocytosis is due to the neutrophilia and that although not significant, the TMONO numbers also decreased as a result of transit. The data suggest than in terms of a hematological response, the transit event may be more stressful than weaning.

Cortisol values in this trial were not significantly effected by weaning or transit. Our samples were collected via jugular venapuncture from calves that were not accustomed to being handled and the observed baseline values were elevated above normal baseline values. Values similar to ours have been reported in cattle in response to transit.[11]

Conclusions

Shrink is an important parameter to be measured in terms of evaluating the degree of stress. Excessive shrink results in increased morbidity, mortality, decreases in production efficiencies as well as a direct monetary loss to the producer. One should remember that if cattle are purchased from a sale barn or order buyer facility, the shrink calculated from pay weight should be increased by approximately one-third to account for losses during weaning and transit to that facility. If an attempt is made to decrease the amount of shrink, one should probably attempt to decrease the rate of passage of ingesta and urinary excretion. The changes in metabolism must be considered when treating animals therapeutically. Metabolites are formed which must be processed and/or excreted via the hepatic or renal system, therefore care must be exercised when choosing antimicro-bial therapy.

It has been clearly shown that stress causes an increase in serum cortisol concentrations and research indicates that this may impair the immune system in terms of antibody production, mitotic activity of lymphocytes, and neutrophil function. It is probably not possible to prevent all stress, but efforts should be made to minimize stress via good management practices beginning at the farm of origin. Castrating and dehorning should be done at an early age, calves taught to eat from a bunk before they are weaned, and vaccines administered at a time when there is as little stress on the animal as possible. Research is currently being done to attempt to modulate the immune system via drugs and/or hormones.

TABLE 3. [18] Effect of weaning and transit on the hematological responses in beef calves.

	Weaning		Transit	
	pre	post	pre	post
WBC/Cmm x 1000	10.91 ± .44[a]	10.82 ± .45	9.61 ± .48	10.65 ± .51*
TMONO/Cmm x 1000	8.38 ± .41	7.82 ± .33*	7.26 ± .41	6.92 ± .37
Neutro/Cmm x 1000	2.52 ± .21	2.81 ± .27	2.21 ± .20	3.63 ± .27*
HB g/dl	12.72 ± .16	13.15 ± .16*	12.84 ± .18	12.28 ± .18*

[a] Mean ± SE.
*Pre vs. Post ($P < 0.05$).

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