Comparison of the Bio-Bullet® versus Traditional Injection Techniques on Tissue Damage and Tenderness in Beef Subprimals

M.M. Sullivan, D.L. VanOverbeke, C.R. Krehbiel, J.B. Morgan

Story in Brief

A study was conducted to evaluate the effects of route of injection administration on lesion occurrence, tenderness, and collagen concentration in beef chucks and rounds. Steers (n=192) were blocked by BW (body weight) and randomly allocated to treatment groups: Biobullet containing (100 mg of ceftiofur sodium compounded by The Veterinary Pharmacy, Inc. (Newcastle, OK); needle/Naxcel; Biobullet/BallistiVac IBR; needle/Titanium5; Biobullet containing no pharmaceutical; and needle/water. Initial evaluation of chucks and rounds showed that 83.9% of lesions identified were clear scars resulting from treatment. Warner-Bratzler Shear Force values of chuck lesion cores were tougher than control tissue cores and at points 1 in and 2 in from the core. Biobullet cores were 1.63 lbs higher in shear force value than lesion cores from chucks injected with Biobullet containing no pharmaceutical or Needle/Naxcel treatments. The Biobullet did not create greater incidence of lesions in the chuck or round, nor did more tissue damage than needle injections. Biobullet is not recommended in the round as it does not meet quality assurance guidelines. However, Biobullet can effectively be used in prescapular applications without additional negative effects on tenderness.

Key Words: Beef Tenderness, Biobullet, Injection Administration, Injection Site Lesions

Introduction

The goal of the study was to reveal any relationship between route of injection administration and severity of tissue damage occurring in beef chucks and rounds. The National Cattlemen's Beef Association has worked for more than 15 years on developing the Beef Quality Assurance program to resolve quality challenges such as tissue damage and tenderness complications created by injection-site damage in the top sirloin butt and in muscles of the round. In the late 1990's George et al. (1997) demonstrated that subprimals which contained lesions (visible or non-visible) had higher shear force values and greater tenderness variation than non-injected control subprimals. As a result of research such as this, greater influence was placed on moving injections to the neck region for all routes of administration of pharmaceutical products. More recently, SolidTech Animal Health Inc., Newcastle, OK has devised a method for injectable administration that uses an air-powered delivery system and biodegradable projectiles containing products such as freeze-dried ceftiofur sodium antibiotic. These Biobullets penetrate into the animal's muscle and begin to be absorbed. Morgan et al. (2004) conducted a preliminary study on the impact of these Biobullets on tissue damage and tenderness in beef rounds. Morgan et al. (2004) documented that visible tissue damage was limited in cattle that were treated with Biobullets 21, 28, and 35 d before slaughter. While the research conducted by Morgan et al. (2004) indicates that the Biobullet administration method of ceftiofur sodium, when used at least 30 d prior to harvest, led to no detectable increase in tissue damage or tenderness, no comparisons between the Biobullet and traditional administration techniques have been made.

Materials and Methods

Cattle. Steers (n = 192) of known treatment history were selected and transported to the Willard Sparks Beef Cattle Research Center at Oklahoma State University. Cattle had no previous injections in the neck or round muscles on the animal's right side before the initiation of the trial. On May 19, 2006 (d 0), steers were administered the appropriate treatment injection: standard BioBullet containing 100 mg of ceftiofur sodium compounded by The Veterinary Pharmacy, Inc. (Newcastle, OK) from Naxcel®; a traditional needle and syringe dose of Naxcel; a standard Biobullet containing BallistiVac® IBR; a traditional needle and syringe dose of Titanium 5; a standard BioBullet containing no pharmaceutical product; and a traditional needle and syringe dose of sterile water.

Treatment. In treatments including Naxcel ® ,BallistiVac® IBR, and Biobullet containing no pharmaceutical product and in treatments with traditional needle pharmaceutical injections, cattle were administered the dosage intramuscularly in either the neck (prescapular) or round (lower quarter) region. Biobullet and traditional injections were placed in the same location either in the neck or the round. After completion of the finishing period, steers (n = 191) were transported to Emporia, KS for harvest. Outside round flats (biceps femoris muscle, IMPS #171a) and 2-piece boneless chucks (IMPS #115) from the right side were collected for the trial. After the 14-d aging period, each subprimal (n = 129) was fabricated into 3/4-in steaks. After fabrication, each steak was observed and palpated for the presence of injection-site lesions. When a lesion was identified by a individual trained in lesion identification, the lesion was verbally described using the 5-point classification system, which categorizes lesions as cystic, scar with nodules, mineralized scar, clear scar, or woody callus (Figure 1). If a lesion was present, steaks were identified to represent the center or core of the lesion, and steaks representing areas that were 2.54, 5.08 and 7.62 cm away from the lesion core. If no lesion was found in the subprimal, steaks were taken from the region where the lesion should have occurred (i.e., where the injection was given) along with a control steak for Warner-Bratzler Shear Force testing, proximate analysis and collagen determination.

Figure 1. Example of woody lesion in biceps femoris muscle.

Figure 2. Example of steak with cores taken from lesion center, 2.54 cm away from core and 5.08 cm away from core

Warner-Bratzler Shear Force. Steaks were randomly assigned to cooking order across treatment group and were then broiled on an impingement oven. The Warner Bratzler Shear Force (WBSF) at the lesion site and the average of the WBSF for the four cores at each distance of 2.54, 5.08, and 7.62 cm from the lesion location was calculated and recorded for each steak (Figure 2).

Histological Examination. Histopathological examinations of muscle samples were performed to verify that tissue damage was a result of an injection.

Proximate Analysis. Proximate analysis of the samples was performed in duplicate and averaged according to the procedures outlined by AOAC (1990). Three grams of the powdered sample was placed in filter paper, dried at 100°C for 24 h, desiccated for 1 h, and reweighed to determine moisture, then each sample was placed in a soxhlet for 24 h for ether extraction of lipid. Each sample was desiccated and re-weighed to calculate lipid content.

Collagen Determination. Hydroxyproline is quantitatively determined as a measure of collagenous material in meat and meat products. In calculating the collagenous connective tissue content, the following formula was utilized: B,g /100 g = H X 8. It should be noted that collagenous connective tissue contains 12.5% hydroxyproline if the nitrogen-to-protein factor is 6.25.

Statistical Analysis. All post harvest results were analyzed using General Linear Model (PROC MIXED, SAS Inst., Inc., Cary, NC). However, the interaction was not significant ($P>0.2$) for all variables and it was removed from the model. Because all steers were administered Naxcel and a viral vaccine, only injection technique was included in the final model. Data were analyzed to determine the effect of pharmaceutical, route of administration, and pharmaceutical by route of administration on lesion occurrence, Warner-Bratzler Shear Force, and fat and collagen content. Means were separated when a significant F test ($P = 0.05$) was observed. Means were separated using a pair-wise t-test.

Results and Discussion

Yield and Quality Grade Data. Quality and yield grade data were collected from carcasses before fabrication. There was little difference in yield grade and quality grade between treatment groups. However, it was observed that the Needle Titanium 5 group had the lowest quality grade (Slight 65) and yield grade (2.54). The treatment group with the highest yield grade was Biobullet*Naxcel® (2.94).

Lesion Presence. In regard to product type,visual palpation and inspection of the 69 rounds and 60 chucks that were evaluated identified a visual lesion in 71.83% of all Needle*Water (Control) rounds, which was similar to rounds needle injected with Naxcel, which had a 70.83% visual lesion presence. Rounds injected with Titanium 5 had a visual lesion present in 77.83%, which was the highest percentage of all rounds and chucks. The highest lesion percentage in regard to product injected occurred in chucks injected with Naxcel; 65.04% of chucks had a visible lesion. Although lesion occurrence was not significantly different ($P>0.10$) between the two routes of administration, 83.33% of rounds treated with a Biobullet had a visible lesion as compared to 63.66% of rounds treated using a needle, 56.25% of chucks treated with a Biobullet, and 57.08% of chucks injected with a needle (Table 1). The types of lesions found in the chucks and rounds included clear scars and woody calluses, as well as metallic and nodular lesions. The majority of the lesions identified were clear scars (83.7%) in the chuck and round. In the 2-piece chucks that were evaluated, there were 14 lesions that were found in the clod as compared to the 57 lesions that were identified in the chuck roll. Lesions found in the chuck roll and clod were commonly found in seam fat between the muscles, whereas the lesions found in the round were generally found in lean muscle tissue. In several instances, clear lesions found in the eye of round were long and narrow white tracks going across the grain of the muscle fiber. These results indicated variable lesion type and occurrence in beef sub-primals from treatment route and product type.

Table 1. Lesion presence percentage in beef subprimals (n = 129)[1] stratified by product

	Biobullet	Needle	SEM	P > F2
Round	83.33%	63.66%	1.3	.51
Chuck	56.25%	57.08%	5.9	.31

[1]N = 129: n = 69 for round by product type; n = 60 for chuck by product type

[2]Probability of overall F test

Histology. Histological examination of all samples confirmed the diagnosis of injection site lesions as described by George et al. (1995). It was noted that lesions within sections of all eight specimens revealed variable evidence of chronic fibrosing inflammation involving skeletal muscle and adipose tissue. In all steaks evaluated there were mature fibrous tissue and collagen fibers within adipose tissue.

Tenderness. No differences between injection methods existed in the tenderness of rounds in control steaks, lesion centers, or at 2.54, 5.08, or 7.62 cm from the lesion center (Table 2). Warner-Bratzler Shear Force values of lesion site center in chucks tended to be significantly different (P=.7) than cores from the control and 2.54 and 5.08 away from the core. Lesion cores from the Biobullet* BallistiVac® IBR had a WBSF value of 15.45 lb, which were significantly different (P<.05) from lesion center cores from chucks injected with a Biobullet containing no pharmaceutical product or a Needle*Naxcel where WBSF values were 13.82 lb and 11.20 lb, respectively (Table 3). However, this contradicts research conducted by Morgan et al. (2004) in which only steers treated with a Biobullet injection at 7 or 14 d before harvest displayed the presence of injection lesions in the biceps femoris; thus, no detrimental effects on beef tenderness would likely be realized with Biobullet treatment 21 d or more before slaughter. The steak for the same interactions of Biobullet* BallistiVac® IBR, BioBullet containing no pharmaceutical product, Needle*Naxcel were 10.54 lb, 10.43 lb, and 10.16 lb, respectively. WBSF values for samples 7.62 cm away from the lesion center were significantly different in shear force values, with the toughest samples resulting from the needle*H20 interaction group (14.0 lb).Warner-Bratzler Shear Force values for chuck steaks taken at 1 in and 2 in away from the lesion core were not significantly different, although in all instances by product or by route, those samples required more force to shear than those of the control chuck steaks. Tenderness is a key factor in satisfaction for beef consumers. If there are injection lesions present, it will likely affect a large portion of the cut of meat and consequently increase the odds of an unpleasant eating experience and a dissatisfied customer.

Table 2. Warner-Bratzler Shear Force values (lb) in beef rounds (n = 51)[1] stratified by route of administration

	Route of Administration			
Sample Location	Biobullet	Needle	SEM	P > F[2]
Control[3]	11.81	11.06	.24	.16
Lesion Core	11.37	11.92	.17	.78
2.45 cm from Core	10.33	11.39	.33	.21
5.08 cm from Core	10.75	12.05	.41	.26
7.62 cm from Core	10.42	10.80	.11	.62

[1]N = 51: n = 30 for Bio-Bullet; n = 21 for Needle.

[2]Probability of F Test

[3]Sample from same muscle in same round or chuck with lesion, but excised on opposite end of muscle from lesion

Collagen Content. Tenderness is impacted by the amount of collagen and connective tissue that occurs in the muscle. When a wound or injury occurs, the healing process involves the deposition of connective tissue and collagen in and around that wound. There were no significant differences (P>0.05) observed in the total collagenous connective tissue in samples extracted from the chuck or round.

Lipid Content. Lipid concentrations also vary with tenderness and muscle damage, as increased amounts of fat create more tender beef in post mortem muscle. When damage occurs in living muscle, fat deposition increases. The comparison between the lesion site and control (no lesion site) samples for lipid concentration showed no significant difference for route or product in the round.

Conclusions

Although injection-site lesions are decreasing in prevalence, new technologies have given a new twist to the traditional needle and syringe. Utilizing these new methods of administration may ease the stress of handling livestock several times for repeated vaccination, but concern must be raised in that the emerging technology causes similar amounts of tissue damage in valuable muscle. From a production standpoint, the results indicate that it is still best to administer vaccines to cattle anterior to the scapula to decrease the chance of lean tissue being damaged, resulting in trim loss and tenderness. Moreover, we can estimate losses due to extra handling of animals, trim loss, etc, but we cannot calculate the cost of a lost consumer due to poor beef palatability as a result of an injection lesion.

Table 3. Warner-Bratzler Shear Force valued (lb) in beef chuck lesion site cores stratified by product * route interaction.

Route * Product	Control[1]	Lesion Center
Bio-Bullet * BallistiVac® IBR[2]	10.53	15.45[a]
Bio-Bullet * no product[3]	10.42	13.82[ab]
Needle * Naxcel[4]	10.16	11.19[abc]
Needle * Titanium 5[2]	9.78	10.27[bc]
Needle * H20[3]	9.45	10.16[bc]
Bio-Bullet * ceftiofur sodium[4]	10.64	8.39[c]
SEM	.31	.15
P > F[5]	.93	.05

[a,b,c] Within a column, means without a common superscript letter differ ($P < .05$)

[1]Sample from same muscle in same round or chuck with lesion, but excised on opposite end of muscle from lesion

[2]Represents rounds injected with Titanium 5, a modified live vaccine for IBR, BVD, BRSV, and PI3

[3]Represents rounds injected with control (saline) solution or no pharmaceutical product.

[4]Represents rounds injected with Naxcel, a ceftiofur sodium product

[5]Probability of F Test

Literature Cited

George, M. H. et al. 1995. J Anim. Sci. 73:3510-3518.

George, M. H. et al. 1997. Compendium's Food Animal Medicine and Management. 19(2):S84-S93.

Morgan, J. B. et al. 2004. J. of Anim. Sci. 82:3308-3313.

Authors

Sullivan, Micca - Graduate Student

VanOverbeke, Deborah - Assistant Professor, Animal Science

Krehbiel, Clinton - Associate Professor, Animal Science

Morgan, Brad - Professor, Animal Science