Food Animal Economics

Cost-effectiveness analysis of treatment alternatives for beef bulls with preputial prolapse

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Objective—To develop an economic model for comparing cost-effectiveness of medical and surgical treatment versus replacement of beef bulls with preputial prolapse.

Design—Economic analysis.

Sample Population—Estimates determined from medical records of bulls treated for preputial prolapse at our hospital and from information about treatment of bulls published elsewhere.

Procedure—Annual depreciation cost for treatment (ADC_T) and replacement (ADC_R) were calculated. Total investment for an injured bull equaled the sum of salvage value, maintenance cost, and expected cost of the treatment option under consideration. Total investment for a replacement bull was purchase price. Net present value of cost was calculated for each year of bull use. Sensitivity analyses were constructed to determine the value that would warrant treatment of an injured bull.

Results—The decision to treat was indicated when ADC_T was less than ADC_R. In our example, it was more cost-effective for owners to cull an injured bull. The ADC_R was $97 less than ADC_T for medical treatment ($365 vs $462) and $280 less than ADC_T for surgical treatment ($365 vs $645). Likewise, net present value of cost values indicated that it was more cost-effective for owners to cull an injured bull. Sensitivity analysis indicated treatment decisions were justified on the basis of replacement value or planned number of breeding seasons remaining for the bull.

Clinical Implications—The model described here can be used by practitioners to provide an objective basis to guide decision making of owners who seek advice on whether to treat or replace bulls with preputial prolapse. (*J Am Vet Med Assoc* 1997;211:856–859)

Preputial injuries are one of the more common problems limiting breeding ability of beef bulls placed in a breeding pasture.[1,2] Prolapsed preputial epithelium with accompanying edema and epithelial excoriation, ulceration, or laceration account for most injuries. This is not a life-threatening injury and generally responds favorably to treatment; however, timing of the injury often precludes use of the bull for the current breeding season.

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Preputial prolapse is a common ailment hindering reproductive function in bulls examined at our veterinary teaching hospital. Despite the prospect of being unable to use a bull for an entire breeding season as well as spending a considerable sum of money on treatment costs, about two thirds of owners elect treatment of bulls examined for preputial prolapse. However, in the experience of some of the authors (TRK, RNH), some owners have difficulty making this decision. Ultimately, a subjective estimate of the worth of an injured bull is used to formulate their decision. Our aim was to develop an objective method for determining the economic consequences of medical and surgical options for treatment of a bull with preputial prolapse. The goal was to assist those owners that seek economic guidance to enable them to make an informed decision about treating or culling an injured bull.

Materials and Methods

Economic model selection—Cost-effectiveness analysis, a variant of cost-benefit analysis,[3] is a method that can be used to evaluate economic ramifications of health management decisions in bulls. In the cost-effectiveness analysis model that we used, annual depreciation cost and a capital budgeting technique were used to compare the economic consequences of a decision to treat versus replace (cull) a bull with preputial prolapse.

Model equations—**Annual depreciation cost for treatment (ADC_T) and replacement (ADC_R)** were calculated, using the standard equation: ADC = (total investment − salvage value)/remaining number of breeding seasons. Total investment for an injured bull equaled the sum of the salvage value of that bull at the end of a planned number of breeding seasons, expected cost for the treatment option under consideration, and maintenance cost accumulated for the breeding season in which the injured bull was not used. Total investment for the replacement bull was purchase price.

Net present value (NPV) of cost was used to account for the time value of money and, thus, discount future cash flows.[4] The NPV of cost was computed for each year of bull use, using the equation: $NPV = C/(1 + r)^n$, where C was the annual accumulated cost of expenditures for the injured or replacement bull, r was the annual interest rate (%), and n was the number of years in the future.[3]

Model input values—Variables needed to calculate the equation for annual depreciation cost and NPV of cost were determined. A value was assigned for each variable for illustration purposes only to indicate the type of economic results generated by each model.

Number of breeding seasons remaining for the injured bull and a replacement bull of equal genetic quality—Bulls used in commercial beef cow-calf enterprises are typically retained for 4 or 5 breeding seasons depending on whether the animal is purchased as a 2 year old or yearling, respectively.[5] For our analysis, a replacement bull was used for 5 breeding seasons. It was assumed that an injured bull was beginning the third of 5 breeding seasons. The bull was not used in the current breeding season after it sustained an injury. At the end of 2 additional breeding seasons after successful recovery from injury, the bull would be replaced.

Purchase price of a replacement bull—In the model, $2,500 was allocated to purchase a replacement bull of genetic quality equal to the injured bull.

Salvage (cull) value for injured and replacement bulls—Body weight (kg [lb]) and sale price ($/kg [$/lb]) for current livestock auctions are required to establish a reasonable salvage value for an injured bull. In contrast, the future salvage value of a replacement bull at the end of its productive life as a breeding animal is speculative. Historical data on the sale price of cull bulls may be useful in estimating a future salvage value. To simplify the comparison, a salvage value of $675 (682 kg X $0.99/kg [1,500 lb X $0.45/lb]) was used for all bulls.

Annual cost of maintaining a bull—Annual costs associated with maintaining a bull were approximated at $400/bull/y.[5] A $400 maintenance cost was allocated to an injured bull for the breeding season in which the injury was incurred and the bull was not used.

Probability estimate of successful outcomes of medical and surgical treatments for preputial prolapse—Memon et al[1] reported that 16 of 24 (67%) bulls with preputial prolapse returned to breeding after medical treatment alone. At our hospital, 7 of 15 (47%) bulls with preputial prolapse that were hospitalized between January 1993 and November 1995 and treated medically recovered and were able to breed cows. Combining these populations, a probability of 0.59 (23/39 bulls) appeared reasonable to use for predicting the likelihood of medical intervention alone in successfully returning a bull with preputial prolapse to functional breeding status.

Likelihood of restoring functional breeding status is improved when medical treatment is coupled with surgical correction of preputial lesions. We combined successful outcomes reported in the literature (100/119 bulls)[1,6-9] with those achieved at our hospital (10/10 bulls treated surgically between January 1993 and November 1995 that were available for follow-up monitoring were able to breed cows) to arrive at a probability estimate of 0.85 (110/129 bulls), which was used to predict the likelihood of surgical intervention in successfully returning a bull with preputial prolapse to functional breeding status. These probability estimates served as a baseline for generating an expected cost of treatment (cost/percentage of successful outcomes).

Cost of medical and surgical treatments for preputial prolapse—A realistic cost to use for medical and surgical treatment of preputial prolapse was determined from expenditures on 27 bulls treated at our hospital between January 1993 and November 1995. Fifteen bulls received medical treatment only. Mean cost of medical treatment was $310/bull (physical examination [$15], hospitalization [12 days, $144], medications and supplies [$31], and professional services [$120]). Mean cost of surgical treatment for 12 bulls was $757/bull (physical examination [$15], hospitalization [24 days, $300], preoperative medical treatment [$80], surgery and professional services [$350], and postoperative medications and supplies [$12]). Using the success rates of the respective treatment modality, an expected cost of $525 ($310/0.59) was calculated for medical treatment and $890 ($757/0.85) was calculated for surgical treatment.

Interest rate—An interest rate of 10% was used.

Sensitivity analysis—Sensitivity analysis provides a means to test how a given financial outcome reacts to changes in variables having influence on the financial outcome. We constructed a sensitivity analysis, using annual depreciation cost, to determine the value that would warrant treatment of a bull with an injured prepuce (value at which annual depreciation cost for a replacement bull [cull option] and a bull with preputial prolapse receiving medical treatment [treatment option] would be the same). A second sensitivity analysis was executed for a surgical treatment option. The variable that was altered to change annual depreciation cost for the injured bull was number of breeding seasons retained after injury.

Results

The decision to treat a bull with preputial prolapse was economically supported only when projected annual depreciation cost in the aftermath of veterinary care (ADC_T = [{salvage value + maintenance cost + expected treatment cost} – salvage value]/remaining breeding seasons) was less than the projected total annual depreciation cost for a purchased replacement bull (ADC_R = [purchase price – salvage value]/remaining breeding seasons).

Given the results of ADC_T for a bull with preputial prolapse and ADC_R for that of a replacement bull (Table 1), it was more cost-effective for owners in our example to cull the injured bull. The ADC_R was $97 less than ADC_T for medical treatment ($365 vs $462) and $280 less than ADC_T for surgical treatment ($365 vs $645). Likewise, analysis of results of NPV of cost calculations indicated that it was more cost-effective for owners to cull the injured bull. However, magnitude of monetary differences were greater ($1,179, $1,373, and $1,739 for bull replacement, medical treatment, and surgical treatment, respectively) because of the important influence that time had on the value of money at the point when a treatment decision was made.

Under the specific constraints for bull value and remaining breeding seasons that were used to calculate ADC_T, ADC_R, and NPV of cost in the cost-effectiveness analyses reported here, treatment was warranted only when an injured bull was more valuable monetarily (higher replacement cost than that used in our example) or when an owner retained an injured bull for more breeding seasons than usual. This was illustrated in sensitivity analyses for medical and surgical treatment. The ADC_T for medical treatment of a bull that would be used for an additional 5 years was $925, $462, $308, $231, and $185 for years 1 through 5, respectively; however, value at which treatment was favored over culling was $5,300, $2,985, $2,215, $1,830, and $1,600 for years 1 through 5, respectively. Thus, medical intervention would have been justified outright when an injured bull in the example reported here had been valued at more than $2,985 (ie, for the same ADC_T that would have reflected the amount of

Table 1—Analysis to evaluate cost-effectiveness of medical and surgical treatment alternatives versus culling for a bull with preputial prolapse, using a model to determine annual depreciation cost

	Treatment decision		
Variable	**Medical**	**Surgical**	**Replace**
Remaining No. of breeding seasons (y)*	2	2	5
Cost of replacement bull ($)	NA	NA	2,500
Cull or salvage value			
Weight (kg)†	682	682	682
Net price ($/kg)‡	0.99	0.99	0.99
Calculated value ($)§	675	675	675
Mean cost of surgical treatment ($)	310	NA	NA
Expected success rate (%)	59	NA	NA
Expected cost ($)‖	525	NA	NA
Mean cost of surgical treatment ($)	NA	757	NA
Expected success rate (%)	NA	85	NA
Expected cost ($)‖	NA	890	NA
Maintenance cost for year of injury (not used for breeding; $)¶	400	400	NA
Total investment ($)#	1,600	1,965	2,500
Annual depreciation cost ($)**	462	645	365

*Assumes that owner typically purchases the bull as a yearling and sells it after 5 breeding seasons. In this example, the replacement bull was used for 5 breeding seasons, whereas an injured bull was beginning the third breeding season and was precluded from use for that breeding season. †To convert to weight in lb, multiply by 2.2. ‡To convert to net price of $/lb, divide by 2.2. §Calculated value ($) = weight (kg) × net price ($/kg). ‖Expected cost = mean cost of treatment/expected success rate. ¶Value from reference 5. #For an injured bull, total investment cost = salvage value + expected cost of separate medical and surgical treatment + maintenance cost, whereas for a replacement bull, total investment cost = purchase price. **Annual depreciation cost = (total investment–salvage value)/remaining No. of breeding seasons.
NA = not applicable.

money spent on medical treatment [$462], an owner could have invested $2,985 for the purchase of a replacement bull). Alternatively, a bull valued at $2,500 would have to be kept for 3 breeding seasons instead of the planned 2 remaining years to justify cost of medical treatment.

For surgical treatment, the ADC_T for surgical treatment of a bull that would be used for an additional 5 years was $1,291, $645, $430, $322, and $258 for years 1 through 5, respectively; however, value at which treatment was favored over culling was $7,130, $3,900, $2,825, $2,285, and $1,965 for years 1 through 5, respectively. Thus, when treated surgically instead of medically, the same injured bull would need to be kept for 4 breeding seasons instead of the planned 2 years. Alternatively, surgical intervention would be justified outright when an injured bull was valued at > $3,900.

Discussion

The decision aid described was not designed or intended to place veterinarians in the position of making the decision for an owner who must determine whether an injured bull should be treated. To the contrary, this cost-effectiveness model was designed to expand the amount of information that a veterinarian can provide to clients so that producers can make their own decision about the appropriate course of action. Furthermore, it is unlikely that every producer would take advantage of this economic decision aid when deciding about the course of action for managing a bull with preputial prolapse.

Obviously, when a bull from a single-sire herd incurs a preputial injury at the start of the breeding season, a replacement must be purchased to breed cows. The same would apply for a bull from a multi-sire herd, provided the bull was needed to maintain a sufficient number of bulls for the herd to ensure adequate pregnancy rates. During a long-term period, however, an owner may still opt to seek information from this decision aid when determining whether an injured bull should be treated and kept for future breeding seasons, particularly for bulls with high genetic merit. Veterinarians will also have clients that will insist on treatment irrespective of cost because of a high value placed on genetic merit of a bull. In contrast, producers that own modestly priced ($1,500 to $2,500) injured bulls are the ones that this cost-effectiveness analysis was designed to help the most with decision making. In the experience of the senior author (TRK), the latter group of producers are most likely to ask a veterinarian for their opinion about a course of action.

Given the constraints on values placed in the cost-effectiveness models for ADC_T, ADC_R, and NPV of cost, medical treatment was more cost-effective than surgical intervention in both models. Monetary differences were greater using NPV of cost. The NPV of cost was a more precise economic method for comparing the flow of revenue and acquired cost acquired throughout time. However, it was more time-consuming to enter values in the correct chronologic order for NPV of cost, compared with data entry for ADC_T or ADC_R. Consequently, it would probably be most practical for veterinarians to routinely use ADC_T or ADC_R to guide initial decision making for this particular health management issue. Use of NPV of cost would be valuable in instances when the ADC_T for 1 or both treatment options and ADC_R were equivocal or when 1 or both treatment options provided only a slight advantage over culling.

Veterinarians that are inspired to use this decision aid in a clinical setting must accept and maintain a mindset to supply up-to-date relevant data. To do otherwise defeats the purpose of a cost-effectiveness analysis as a dynamic decision tool. Only 5 pieces of information are needed to generate a cost-effectiveness analysis on the basis of annual depreciation cost. These items are expected cost of treatment option, maintenance cost, salvage value, replacement bull price, and number of remaining breeding seasons. Treatment is favored when ADC_T is less than the cost of replacement. The only additional information needed to determine NPV of cost was an interest rate. Consequently, veterinarians must take the time to determine in advance their costs for medical and surgical treatment of a bull with preputial prolapse and the associated success rate for each treatment option. Veterinarians should also be aware of current slaughter prices of bulls and interest rates. Likewise, owners must provide information about the replacement cost for the injured bull, additional number of breeding seasons the injured bull will be used, a reasonable estimate of maintenance costs for herd bulls, and the number of years purchased bulls are used.

An argument can be made that when a bull's specific genetic merit is needed in a herd, use of replacement cost as a measure of genetic worth to decide whether to treat versus not to treat (cull) is inappropriate. The premise would be that the particular bull's genotype, as reflected in phenotypic responses of offspring, cannot be replaced (duplicated). Thus, because comparable bulls do not exist, it would be unnecessary to consider replacement cost, and treatment would always be indicated. However, with the advent of expected progeny differences, an objective method exists to characterize the genotype of a bull for specific traits (eg, birth weight, calving ease, growth, maternal strength of daughters).[10] When producers use a bull from one of the major beef breeds in the United States, this information can be accessed by contacting the respective breed association office and their expected progeny differences database. Consequently, bulls can be matched for similar genetic merit. Notwithstanding, a bull is still considered an expense to a beef cattle enterprise.[11] The amount of bull expense is a function of the bull-to-cow ratio used by each ranch and is expressed in terms of bull cost ($) per cow exposed during the breeding season.[5] An economic value can, and must, be placed on even one-of-a-kind bulls.

Our cost-effectiveness analysis favored treatment over culling for bulls of indispensable genetic merit, providing indispensable genetic merit was synonymous with a high replacement price. For example, using values for a 682-kg (1,500-lb) injured bull with 2 breeding seasons remaining (Table 1), we determined that this bull should be treated outright only when projected ADC_T of medical treatment ($462) was less than ADC_R. Thus, the bull must be worth more than $2,985 ([$462 × 5 years of bull use] + $675 salvage value) instead of the $2,500 that was used in our example to favor treatment over replacement. If the same bull was injured with 1 breeding season remaining, the ADC_T would increase to $925. Replacement value must be more than $5,300 ([$925 × 5 years of bull use] + $675) to favor treatment outright.

This decision aid was designed for use with an electronic spreadsheet programs.[a,b] For busy practitioners, an electronic spreadsheet provides tremendous speed for determining the economic importance of each option in this particular cost-effectiveness analysis. Once the required variables were entered into the appropriate cells containing the stored equations, calculations were instantaneously performed and results were posted. Within seconds, clients were provided with the information needed to make an informed decision.

[a]Excel 5 for Windows, Microsoft Corp, Redmond, Wash.
[b]Lotus 1-2-3 97 for Windows 95, Lotus Development Corp, Cambridge, Mass.

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