Atresia Coli in Calves: Etiopathogenesis and Surgical Management

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Abstract

Atresia coli is a congenital abnormality in cattle that is lethal without surgical correction. Although the condition has been reported predominantly in the Holstein-Friesian breed, the inheritance of atresia coli remains controversial and not completely understood. A systematic review of published cases and hospital-based case-control study were undertaken to evaluate breed as a risk factor for atresia coli in cattle, and to determine the best method for surgical management. Systematic review of 37 published studies indicated that atresia coli has been diagnosed in 10 cattle breeds and 12 countries, with the marked preponderance of cases occurring in Holstein-Friesian calves. Epidemiologic analysis indicated that Holstein-Friesian cattle were at significantly greater risk for the condition than all other dairy cattle breeds ($P < 0.0001$) and all other cattle breeds ($P < 0.0001$). Atresia coli probably occurs secondary to vascular insufficiency of the developing colon in calves. Holstein-Friesian cattle are predisposed to atresia coli, probably because their developing colon grows at a faster rate and/or to a greater extent than that in other cattle breeds. Early or vigorous palpation per rectum of the amniotic vesicle appears to increase the risk of atresia coli in a predisposed fetus, probably through palpation-induced damage to the rapidly developing colonic vasculature. Surgical correction of atresia coli had a poor overall success rate (short term survival rate was <50%) and long term survival rate (<35%). Because of the poor survival rate, expense, and potential for propagation of a genetic defect, definitive surgical correction should not be routinely performed on affected Holstein-Friesian calves.

Introduction

Atresia coli is a congenital abnormality in cattle that is lethal without surgical correction (1). The condition has been reported predominantly in the Holstein-Friesian breed, although sporadic cases have been reported in other breeds. The inheritance of atresia coli remains controversial and not completely understood. Because surgical correction of atresia coli in calves is being attempted with increasing frequency, an important issue to be resolved is whether atresia coli is a heritable condition in cattle.

A number of studies indicate that atresia coli is inherited in cattle. Syed and Shanks (2) examined the pedigrees of dams and sires of affected and unaffected calves in an Illinois herd and concluded that atresia coli was inherited in a homozygous recessive manner, and that palpation per rectum before 40 d of gestation was a contributing factor but not essential for all cases of atresia coli in this breed. Syed and Shanks estimated the minimum gene frequency of atresia coli in US Holstein-Friesian cattle to be 2.6 % (2). Smith et al (3) reported that 32 normal calves and 1 calf with atresia coli were born following breeding of 11 surgically-corrected heifer calves; this rate was similar to that predicted (33 x 0.026 = 0.9 calves), assuming that atresia coli is an inherited condition in cattle.

The results of breeding studies conducted by Willer et al (4) and Ducharme et al (5) provide the strongest argument against atresia coli being inherited in a homozygous recessive manner. These investigators surgically corrected a total of 7 Holstein-Friesian calves born with atresia coli and bred the animals; of the 15 calves born from this process, none had atresia coli. Willer et al (4) also studied the hereditary aspects of atresia coli in German cattle and concluded that the condition was not inherited in a simple autosomal recessive manner. They calculated heritability to be 0.0875, which is not high for a quantitatively heritable trait. Muller et al completed a similar study and concluded that the condition was inherited, but not in a simple autosomal recessive manner (6). They estimated heritability to be 0.0726. Other arguments against a genetic cause include the sporadic nature of cases, multiple breed involvement, occurrence of cases in a number of countries, a report of atresia coli in only 1 calf of a set of identical twins, and association with palpation per rectum in early pregnancy diagnosis (1,7). Early pregnancy diagnosis in cattle by amniotic palpation has the potential to disrupt organogenesis. When performed before day 42 of gestation, amniotic vesicle palpation is associated with atresia coli in a frequency-dependent manner (6,8).

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There is therefore considerable controversy regarding the heritability of atresia coli. Moreover, if atresia coli is a heritable condition, it is not clear as to what factor is inherited. The primary purpose of this study was therefore to evaluate breed as a risk factor for atresia coli in cattle, specifically to confirm suggestions that Holstein-Friesian cattle are genetically predisposed to developing atresia coli. The secondary objective was to develop a cohesive hypothesis for the development of atresia coli that accounts for the apparent breed predisposition and association with palpation per rectum for pregnancy diagnosis. The final objective was to provide recommendations for the best method to surgically correct calves with atresia coli.

Materials and Methods

Articles on atresia coli published in English, French and German between 1973 and 1995 were examined and information regarding breed and surgical management of affected calves retrieved.

Information concerning selected epidemiologic factors of calves with atresia coli was obtained by a computer-assisted search of hospital records performed by the Veterinary Medical Data Program (VMDP). The computer search identified all calves less than 2 months of age diagnosed with atresia coli that were admitted to 18 North American veterinary schools between March 1, 1964 and October 31, 1993 and all similarly aged, unaffected calves admitted over the same period. A hospital-based case-control study was then conducted to evaluate breed as a risk factor for atresia coli. The hospital population was dichotomously classified into those with the condition (cases) and those without the condition (hospital controls). Significance was identified at $P < 0.05$.

Results

Thirty-seven articles describing atresia coli in cattle were obtained. Of these articles, 22 studies provided sufficient information regarding breed of affected calves. Atresia coli was diagnosed in 10 pure-bred cattle breeds, with the marked preponderance of cases occurring in Holstein-Friesian calves. Cases were reported in 497 dairy calves: 485 Holstein-Friesian, 8 Holstein-Freisian x Jersey crossbred, 2 Ayrshire, 1 Guernsey and 1 Brown Swiss. Cases were also reported in 17 beef or crossbred calves: 6 Angus, 4 Simmental, 2 Shorthorn, 2 crossbred, 1 Maine-Anjou, 1 Hereford, and 1 Polled Hereford. Cases were reported in 12 countries, including Australia, Belgium, Canada, France, Germany, Great Britain, Italy, Ireland, Japan, the Netherlands, Switzerland, and the United States. Of the 9 articles that described the surgical management in sufficient detail, it appeared that approximately 40% of calves that had a colocolic anastomosis or cecostomy performed left the veterinary hospital alive (Table 1).

Table 1. Survival data after surgical correction.

No. calves	No. alive at discharge	No. alive at 2 years	Reference
Colocolic anastomosis			
3	1 (33%)	0 (0%)	9
4	0 (0%)	0 (0%)	10
43	18 (42%)	0 (0%)	11
43	19 (44%)	<15 (<35%)	12
23	9 (39%)	2 (9%)	7
12	5 (42%)	4 (33%)	13
61	27 (44%)	10 (16%)	3
Cecostomy or colostomy			
6	1 (17%)	0 (0%)	10
10	7 (70%)	0 (0%)	11
1	1 (100%)	0 (0%)	14
5	3 (60%)	0 (0%)	15
1	0 (0%)	0 (0%)	7
10	0 (0%)	0 (0%)	16

Long term follow-up information was scant. In general, it appeared that no more than 16 % of calves undergoing colocolic anastomosis and 0 % of calves undergoing cecostomy or colostomy survived until 2 years of age. Although some of the animals discharged from hospital were slaughtered for meat as veal calves or yearlings, there still appeared to be a higher than expected mortality rate in surgically corrected animals. Moreover, some of the surviving animals were reported to have slower growth rates and more watery feces than their herd mates (3,7,12). End-to-side colocolic anastomosis appeared to produce a similar percentage of calves discharged from hospital (15/27; 56 %) to that achieved by side-to-side colocolic anastomosis (28/53; 53%; $P = 0.82$; [3,12]).

The VMDP data base search identified 291 cattle with atresia coli from a total of 28,373 admissions of male and female calves < 2 months of age, producing a proportional morbidity rate of 10.3 cases per 1,000 admissions. The risk of being born with atresia coli was significantly greater for Holstein-Friesian calves than for all other dairy cattle breeds combined (odds ratio [OR], 4.55; 95% confidence interval [CI], 2.43 to 8.81; $P < 0.0001$) and for all other dairy and beef cattle breeds combined (OR, 7.12; 95% CI, 5.34 to 9.52; $P < 0.0001$), whereas there was no difference in the OR for atresia coli between other dairy cattle breeds (not Holstein-Friesian) and beef cattle breeds (OR, 1.68; 95% CI, 0.83 to 3.34; $P = 0.11$). Comparing individual cattle breeds,

Holstein-Friesian calves were at a significantly greater risk of developing atresia coli than all other breeds except Brown Swiss, Ayrshire, Guernsey, Limousin, Chianina, and Maine-Anjou. These 6 breeds all had fewer than 400 animals examined over the study period, decreasing the statistical power of the comparison. Of the 291 calves with atresia coli, 142 (49%) were recorded as being alive when discharged from the veterinary hospital.

Discussion

The risk of atresia coli in Holstein-Friesian cattle is clearly higher than in other cattle breeds. Although most cases of atresia coli have been diagnosed in Holstein-Friesian calves, the results of systematic review and epidemiologic analysis indicated that atresia coli has occurred sporadically in 12 other cattle breeds and 12 countries. Taken together, these findings indicate that atresia coli can occur spontaneously but rarely in cattle that are not genetically predisposed. It is likely that atresia coli occurs in all cattle breeds secondary to vascular insufficiency of the developing spiral colon, and that in familial lines of Holstein-Friesian cattle the developing spiral colon grows at a faster rate and to a longer length than in other cattle breeds, predisposing the Holstein-Friesian fetus to atresia coli.

Development and differentiation of the bovine colon occurs from Day 22 to Day 112 of gestation (17,18). Mesentery supporting the intestine is visible by Day 27, and the colon appears as a single tube with its associated mesentery by Day 37 (18). By Day 45, looping of the proximal colon is first observed. The cecum and a portion of the ascending colon remains in the umbilical cord until Day 56. Extensive spiraling of the colon and associated blood supply begins at Day 56 of gestation, and is complete by Day 112 (17). Strangulation or damage to the blood vessels supplying the developing embryonic or fetal colon may be followed by colonic ischemia, leading to atretic segments (1,7). The period of spiral colon development in the calf encompasses the period that pregnancy diagnosis by palpation is most commonly undertaken in dairy cattle. The disproportionate number of cases in Holstein-Friesian calves may, therefore, reflect the widespread practice of early pregnancy diagnosis in dairy cattle and associated palpation-induced damage to the developing embryonic or fetal intestinal vasculature. However, the significantly greater risk of atresia coli in Holstein-Friesian cattle compared with that of all other dairy cattle breeds cannot be satisfactorily explained by breed differences in palpation rates or gestational age when pregnancy diagnosis is performed.

An increase in intravesicular pressure associated with amniotic vesicle palpation (during palpation per rectum for pregnancy diagnosis) predisposes developing embryonic or fetal large intestinal cells to injury. Cells most at risk for pressure-induced injury are probably those in the embryonic or fetal abdomen and those in the umbilical cord (such as the small and large intestine), as these cells have minimal supporting structures to protect against a palpation-induced increase in intravesicular pressure. The association between amniotic vesicle palpation and atresia coli in calves probably results from palpation-induced damage to the developing colonic vasculature when the colon is located in the umbilical cord or coelomic cavity.

Holstein-Friesian cattle may be genetically predisposed to developing atresia coli because the embryo and fetus of this breed (and therefore the ascending colon and spiral colon) grow at a faster rate than embryos of other cattle breeds during the first trimester (18,19,20). Rapid embryonic and early fetal growth places an added stress on the colonic vasculature as it migrates with the developing ascending and spiral colon, predisposing the developing colon to ischemia and subsequent atresia. Adult Holstein-Friesian cattle also have a longer intestine than other cattle breeds as a result of selection for the ingestion of concentrates and milk production. Comparative studies of ruminant gastrointestinal anatomy indicate that the large intestine is proportionately longer in ruminants that are concentrate selectors rather than roughage eaters, presumably to facilitate post ruminal fermentation and absorption of hind gut fermentation products. Fermentation in the large intestine makes an important contribution to the total metabolizable energy intake of cattle, particularly when high concentrate diets are fed during early lactation. Although studies of breed variations in intestinal length are not recent, the studies suggest that Holstein-Friesian cattle have longer small and large intestines than other cattle breeds. We suspect that familial lines of Holstein-Friesian cattle have a proportionately longer large intestine, resulting in an increased risk of vascular compromise during embryonic and fetal development of the colon. The hypothesis that Holstein-Friesian cattle have longer intestinal lengths than other dairy breeds is, however, consistent with findings that intestinal length is significantly correlated with milk production (21), and that Holstein-Friesian cattle have the highest average annual milk production.

Based on the above, it is likely that the risk of amniotic vesicle palpation is cumulative or synergistic to the risk of atresia coli in familial lines of Holstein-Friesian cattle. The failure of Willer et al (4) and Ducharme et al (5) to observe atresia coli in calves born from breeding surgically corrected animals may have been due to the absence of early amniotic vesicle palpation. In other words, these cattle may have been predisposed to developing atresia coli, and this predisposition

was present but not expressed in their offspring because amniotic vesicle palpation had not been performed for early pregnancy diagnosis.

Surgical correction of atresia coli does not appear to have a high success rate. Absence of a portion of the colon inevitably results in reduced capability for hind gut fermentation and electrolyte and water reabsorption; it therefore is expected that surgically-corrected animals could have reduced growth rates, increased susceptibility to enteric disease, and more watery feces than unaffected herd mates. Given that colocolic anastomosis is an expensive surgical procedure with a poor long term success rate, it appears that routine correction of atresia coli is not economically appropriate. Utilization of cecostomy or colostomy appears more appropriate, as this surgical method is much easier and quicker to perform than colocolic anastomosis, and can be readily adapted for use in the field.

In conclusion, it appears that familial lines of Holstein-Friesian cattle are genetically predisposed to atresia coli and that early or vigorous palpation per rectum of the amniotic vesicle can increase the probability of developing atresia coli during embryonic and fetal life. This hypothesis is consistent with the etiologic hypothesis for atresia coli proposed by Muller et al (6) in 1982. Based on this hypothesis, we recommend that surgical correction of atresia coli should not be routinely undertaken in Holstein-Friesian calves destined for use as breeding animals without discussing the potential for propagation of a genetic defect. Sires and dams of affected Holstein-Friesian calves should be suspected to be carriers for an allele representing a proportionately longer colon and/or rapid growth of the colon during the embryonic and early fetal period. This allele predisposes the calf to development of atresia coli, but may also be associated with increased milk production because of increased intestinal length. Routine culling of the sire and dam of an affected calf is not recommended, as atresia coli can also occur spontaneously, as evidenced by the comparatively rarer occurrence of atresia coli in other cattle breeds.

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