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Pre-operative and Operative Difficulties During Bovine Caesarean Section in Belgium and Associated Risk Factors

I Kolkman[1,2], G Opsomer[1], D Lips[2], B Lindenbergh[1], A de Kruif[1] and S De Vliegher[1]

[1]*Faculty of Veterinary Medicine, Department of Reproduction, Obstetrics, and Herd Health, Ghent University, Salisburylaan, Merelbeke;* [2]*KaHo Sint-Lieven, Department of Agro- and Biotechnology, Sint Niklaas, Belgium*

Contents

The aim of this study was to describe the difficulties encountered during caesarean section (CS) in practice on mainly Belgian Blue (BB) cows and to identify the associated risk factors. Data were collected using a questionnaire completed by veterinarians of the Ambulatory Clinic of the Faculty of Veterinary Medicine, Ghent University (Belgium), immediately after performing a CS. Results revealed that the BB breed had fewer severe pre-operative problems than animals of other breeds, most probably due to the fact that CSs in this breed are performed in a very early stage of parturition. Mild as well as severe difficulties were more likely to happen during surgery in cows that had undergone a CS before. Cows at their second or third surgery had a significantly higher proportion of larger calves and more skin scar tissue was present, both increasing the risk of abdominal wall muscular and uterine haemorrhage. These factors can all lead to problems with exteriorization and suturing of the uterus; hence special attention is needed when performing a CS on a cow which has experienced the procedure before. The more experienced veterinarians were less likely to report difficulties during the operation than less experienced surgeons.

Introduction

Caesarean section (CS) is a common surgical procedure performed in cattle all over the world, with many different techniques (Arthur et al. 1989; Busch 1993; Clark 1987; Frazer and Perkins 1995; Newman and Anderson 2005; Kolkman et al. 2007). Indications to perform a CS are: immaturity of the heifer (Newman and Anderson 2005), incomplete dilation of the birth canal, irreducible uterine torsion (Schonfelder and Sobiraj 2006), rupture of the uterine wall before calving, relative foetal oversize and deformities of the calf (Vandeplassche 1974; Cattell and Dobson 1990; Dawson and Murray 1992; de 2003). Risk factors for CS that were identified in dairy cows are: a single male calf, a long gestation period and young age at first calving (Barkema et al. 1992).

Whereas in dairy cows a CS is only performed when all other attempts to deliver the calf *per vaginam* have failed, for veterinarians working in Belgium CS has become a first choice approach at parturition through the expansion of the Belgian Blue (BB) breed (Kolkman et al. 2007). This beef breed is characterized by an extreme muscular hypertrophy which originates from an anomaly in the myostatin gene, a single autosomal recessive gene that is located on chromosome 2 (Grobet et al. 1998). In BB animals, this gene is missing a segment of 11 nucleotides causing the gene to be inactive, resulting in a deficiency of the genetic restraint on muscular development. Through the sustained phenotypical selection for muscular hypertrophy, an incompatibility between the size of the pelvis (too narrow) of the cow and her calf (oversized) has developed (Swatland and Kieffer 1974; Coopman et al. 2003). Consequently, BB calves are almost routinely born by CS: only 5–10% are born *per vaginam*, a relatively oversized calf being the most important indication to perform a CS in BB cows (Michaux and Hanset 1986; Hanset 2002). This differs substantially from other breeds. In addition, optimal conditions to perform CS are present in Belgium: short distances to the farm, mild winters not hampering accessibility of the herds, ability of the farmers to detect onset of parturition accurately and to provide adequate assistance during the operation and well trained and skilled bovine veterinarians. Currently, almost 50% of all Belgian farmers own at least one BB cow, and a Belgian bovine veterinarian performs on average 500–1000 CSs per year.

However, it should not be forgotten that every CS, even the routine elective CS, remains a major abdominal operation performed in a contaminated environment. Nevertheless, the procedure itself is performed under surgical sterility to avoid contamination. Still, it cannot be considered to be without any difficulties and/or complications before, during and after the operation. Pre-operative complications include nervous animals, emphysematous foetus, foetal abnormalities and uterine inertia, trauma or rupture (Dehghani and Ferguson 1982; Newman and Anderson 2005). Operative complications include tenesmus, haemorrhage, rumen prolaps (Newman 2008), problems with exteriorizing the uterus (Vandeplassche 1988; Hoeben et al. 1997), adhesions at the time of surgery (Hoeben et al. 1997), peritoneal cavity contamination, excessive trauma to abdominal wall (Newman and Anderson 2005), gastrointestinal trauma, inadequate uterine closure (Dehghani and Ferguson 1982), uterine laceration (Vandeplassche 1988; Dawson and Murray 1992) etc., although information on the occurrence of these problems in BB cows is very scarce.

Most studies have investigated difficulties and complications after CS in breeds other than the BB (Seger et al. 1994; Frazer and Perkins 1995; Vaughan and Mulville 1995; Newman and Anderson 2005). In these breeds, CS is seen as the last resort when all other means to give birth to the calf in a natural way have failed, while BB cows are operated on in an early stage of parturition often without attempting to extract the calf. Study of Hoeben et al. (1997) in the BB breed revealed that the surgeon, parity, increased uterine contractions, the position of the calf and the presence of adhesions

were associated with difficulties of exteriorization of the pregnant horn. It is very important that veterinarians are aware of these factors increasing the risk of complications or difficulties (Hoeben et al. 1997) and, as the success rate of a CS mainly depends on the operation technique (Mijten 1994), it is imperative to perform the surgical procedure *secundum artem* (Kolkman et al. 2007).

The aim of this study was to describe the difficulties encountered during CS, mainly in BB cows, and to identify the associated risk factors. This was achieved by collecting data between January 2005 and July 2006 using a questionnaire completed by the veterinarians of the Ambulatory Clinic of the Faculty of Veterinary Medicine (FVM), Ghent University (Belgium), immediately after CS.

Materials and Methods

General

Between January 2005 and July 2006, a questionnaire was completed whenever a CS was carried out by one of the 18 veterinarians working in the Ambulatory clinic of the FVM. During all surgeries, one final year veterinary student assisted the surgeon.

The CSs in the BB cows were performed mainly for elective reasons. Indications in other breeds (and in BB) to carry out this operation were oversized calves, abnormalities of the calves and deformations of the birth canal.

Operation technique

All CSs were performed on the standing cow on the left side as described by Kolkman et al. (2007). In short, all animals routinely received 0.15 mg of clenbuterol-hydrochloride (Planipart®; Boehringer Ingelheim, Brussels, Belgium) intravenously in the tail blood vessel 5 min before the start of the operation. Aggressive or restless animals were sedated with 0.01–0.016 mg/kg xylazine intravenously (Xyl-M®; VMD, Arendonk, Belgium). Local anaesthesia was achieved by a line block with 3200–4800 mg of procaine hydrochloride with adrenaline (Procaine hydrochloride 4%®; VMD). After delivery of the calf, the foetal membranes hanging out were removed and the uterus was closed with a synthetic absorbable monofilament (polydioxanone, Monodox®; Michel Frère, Ucimont (Bouillon), Belgium, USP 2) using a round needle by a single modified Cushing suture pattern, paying special attention not to expose any suture material. When uterine fluids were excessively contaminated or in case there was a risk of leakage, a two-layer closure was performed. In these cases, the modified Cushing suture was followed by a normal Cushing or Lembert. The peritoneum, the muscles, the subcutaneous tissue and the skin were sutured with a synthetic absorbable polyglycolic acid polymer filament (Surgicryl®; SMI, St Vith, Belgium, USP 2). In heifers, the peritoneum and musculus (m.) transversus abdominis were sutured together with the m. obliquus abdominis internus using a simple continuous everting suture pattern. In older cows with thicker muscle layers, the m. obliquus abdominis internus was sutured separately with a simple continuous pattern. The m. obliquus abdominis externus was always sutured separately with a simple continuous pattern. Next, the subcutaneous tissues were sutured using a continuous mattress pattern. Finally, the skin was closed with a continuous interlocking suture.

All animals received antibiotics intra-abdominal during and intramuscular after the CS in form of procaine benzylpenicilline (12 000 IU/kg, Duphapen®; Fort Dodge A.H., Louvain-la-Neuve, Belgium). Procaine benzylpenicilline with neomycin-sulphate (10 000 IU/kg benzylpenicilline + 5 mg/kg neomycine-sulphate, Neopen®; Intervet, Belgium) was used when post-operative infections were expected (such as recumbency during CS, kicking during CS). At the end, 50 IU of oxytocin (Lactipart 10®; Codifar, Wommelgem, Belgium) was administered intramuscularly to all animals, to produce uterine contractions and to stop diffuse haemorrhage of the uterine wall if present.

Three out of the 18 veterinarians routinely administered epidural anaesthesia (1.5–2 ml procaine hydrochloride 4%®; VMD), whereas the other surgeons administered it only when the cow was excessively straining at the start of the operation.

As no stitches had to be removed, the animals were not routinely revisited by the veterinarian, but the farmer was advised to administer antibiotics for 3 days or more [procaine benzylpenicilline (12 000 IE/kg, Duphapen®; Fort Dodge A.H.) or procaine benzylpenicilline with neomycin-sulphate (10 000 IE/kg benzylpenicilline + 5 mg/kg neomycine-sulphate, Neopen®)].

Questionnaire

The address and name of the farmer were noted as well as the ear tag number, the parity, the CS number and breed of the cow, and the identification of the surgeon. As outlined in Table 1, the questionnaire consisted of two sections; the first focussing on pre-operative information and the second on the operation. The questionnaire was filled in by the veterinarian immediately after the CS. The 18 veterinarians were all trained to record the variables to avoid subjectivity. Afterwards all data were manually entered from the questionnaire into Access 2003 (Microsoft Corp., Zaventem, Belgium).

Veterinarians

All veterinarians graduated from the FVM in Merelbeke, Belgium. Their age ranged between 25 and 55 years at the start of the study. Seven veterinarians had little experience (≤2 years) in bovine practice and performing CS, six had moderate experience (>2 and <5 years) and five were highly experienced (≥5 years). There were thirteen male veterinarians and five female veterinarians.

Data and data management

All data were transferred from Access into Excel 2003 (Microsoft Corp.,) to perform descriptive analyses and were checked for unlikely values. In total, 1286 questionnaires were completed in 109 herds, comprising 1275

Table 1. Overview of information on difficulties gathered on pre-operative and operative aspects of 1275 caesarean sections performed between January 2005 and June 2006

Pre-operative information
Cow
Excitation (anxiety or aggressiveness) and posture of cow at arrival, dilation of the birth canal, status of the allantoic sac, status of the amnionic sac
Calf
Presentation (anterior/posterior), status (alive/dead), size (absolute/relative to mother)[a], presence of foetal parts through cervix
General
Trail traction executed, epidural anaesthesia administered
Operative aspects
General
Abdominal wall muscle haemorrhage present, skin scar tissue present, overfilled/tympanic rumen present/rumen accidentally incised, adhesion(s) present, position of the calf in the uterus (legs or back to the wound/left or right horn), exteriorization of the uterus possible, rupturing of the uterus while exteriorizing, recumbency during CS, tenesmus, incision of a placentome, avulsion of a placentome, ruptured uterine wall (before, during or after exteriorization of the calf), haemorrhage of uterine wall, rupture in broad ligaments of the uterus
Suturing
Haemorrhage placentome sutured, single uterine wall sutured circular[b], uterus closed with interlocking suture (first layer), number of layers sutured, suturing of the peritoneum, suturing of the muscles, subcutaneous suture, skin suture

[a]Estimated by the veterinarian.
[b]This penetrating circular suture can be applied to the uterine wall at both sides of the incision, at one side of the incision or at parts of the uterine wall to stop diffuse haemorrhage.

operations on standing cows. Eleven CSs were performed on recumbent cows and were omitted for analysis. The *full dataset* consisted of information on 1275 CSs from cows belonging to these 109 herds. The *reduced dataset*, randomly omitting one CS from cows that underwent two CSs during the study period (n = 93), consisted of information on 1182 CSs. The herds included in the study consisted of beef (n = 60), dairy (n = 19) and mixed herds (n = 30), and were all clientele of the Ambulatory clinic. Ninety-two per cent (n = 1091) of the cows were of the double-muscled BB breed, while the remaining 7.8% (n = 91) of the animals belonged to other breeds [Holstein Friesian (HF), East Flemish double purpose breed (EF), HF × BB crossbreds and EF ×BB crossbreds]. The BB animals were mainly housed in straw boxes while animals of the other breeds were accommodated in free stalls with cubicles or tie stalls. Most farmers own one or more BB animals or are familiar with the breed. They therefore readily call for assistance at an early stage of parturition and request a CS even in the non-BB herds.

Difficulties listed in Table 1 were categorized as either mild (MD) or severe (SD) for further analyses (Table 2). Mild difficulties were defined as difficulties that need attention, but in principle were never life-threatening. Severe difficulties were defined as difficulties that need special attention because they are potentially life-threatening. All cows were then categorized as having encountered none, mild or severe difficulty during their CS. Animals categorized within the MD-group had one or more mild difficulty (ies) during CS. From the moment one severe difficulty (together with mild difficulties) occurred, the animal was categorized in the SD-group.

Table 2. Categorization of some of the difficulties encountered during performing caesarean section between January 2005 and June 2006 into mild and severe difficulties

Mild difficulty	Severe difficulty
Abdominal wall muscle haemorrhage	Accidental incision of rumen
Overfilled rumen	Pulling off of placentomes
Tympanic rumen	Rupture of uterine wall[a]
Recumbency during operation	Cutting in/off placentomes
Tenesmus without eventration of intestines/uterus	Tenesmus with eventration of intestines/uterus
Adhesions between rumen/abdominal wall	Adhesion between intestines/uterus
Exteriorization of the uterus	Haemorrhage in the uterine wall
	Rupture in broad ligament with/without haemorrhage
	Laceration of uterus suture

[a]Rupture before, during or after exteriorization of the calf.

Statistical analyses

First, univariable analyses were performed using the *reduced dataset* (data on 1182 CSs) to study the associations between three factors [breed (BB, non-BB), number of CS (1, 2, ≥3), the experience of the surgeon (≤2 years, >2 to <5 years, ≥5 years)] and the occurrence of difficulties [e.g., skin scar tissue present/absent (Table 1); Pearson χ^2 or Fisher's Exact test, SPSS 14.0 for Windows, SPSS Inc., Brussels, Belgium]. Odds ratios (ORs) were calculated when appropriate. The significance level for the analyses was set at $p \leq 0.05$.

Second, multivariable, multilevel logistic regression analysis was done using the *full dataset* (data on 1275 CSs), adjusting for clustering of multiple CS per cow and multiple cows per herd by including cow and herd as random effects [MlwiN 1.2 (Rasbash et al. 2000)]. Presence/absence (1/0) of mild (MD) or severe difficulties (SD) per CS was used as outcome variables. Model building was done in two steps. First, univariable associations between the two outcome variables (MD vs no difficulty, SD vs no difficulty) and each of the three aforementioned predictor variables (breed, number of CS and experience of the surgeon) were analysed separately. In the second step, the significant ($p \leq 0.15$) predictor variables were combined in two multivariable analyses with the two aforementioned outcome variables. Using backward elimination (significance set at $p \leq 0.05$), the final two models were selected.

Results

Descriptive and univariable analyses

Table 3 gives an overview of 1275 CSs performed categorized by breed, number of CSs and experience of the surgeon (*full dataset*). No difficulty was reported in 527 (41.3%; BB: 41.9%, non-BB: 33.7%) of the CSs, whereas in 350 (27.5%; BB: 27.6%; non-BB: 26.1%) and 398 (31.2%; BB: 30.4%; non-BB: 40.2%) of the CSs

Table 3. Descriptive statistics of 1275 caesarean sections performed between January 2005 and June 2006

	Belgian Blue				Non-Belgian Blue[a]				
	n	% within column	% within row	% of total (n = 1275)	n	% within column	% within row	% of total (n = 1275)	Total
No. of caesarean section									
1	529	44.7	88.3	1.5	70	76.1	11.7	5.5	599
2	359	30.3	95.7	28.2	16	17.4	4.3	1.3	375
≥3	295	24.9	98.0	23.1	6	6.5	2.0	0.5	301
Total	1183				92				1275
Experience of veterinarian[b]									
Low (7)	459	38.8	92.4	36.0	38	41.3	7.6	3.0	497
Medium (6)	214	18.1	91.8	16.8	19	20.7	8.2	1.5	233
High (5)	510	43.1	93.6	40.0	35	38.0	6.4	2.7	545
Total	1183				92				1275

[a]Holstein Friesian (HF), East Flemish (EF), Belgian Blue (BB), HF × BB crossbreds and EF × BB crossbreds.
[b]Low: ≤2 years, medium: >2 to <5 years, high: ≥5 years of experience.

mild and severe difficulties were reported, respectively. Three cows died within 2 days after the operation and necropsy showed that two animals died due to haemorrhage of a placentome and the third animal because of peracute peritonitis.

Upon arrival at the farm, almost 5% of the cows were recumbent and nearly 10% were excited (Table 4). Belgian Blue cows were less likely to be recumbent upon the arrival of the veterinarian at the farm compared with non-BB cows [OR (±95% Confidence

Table 4. Overview of the preoperative findings and difficulties and their association with breed and caesarean section number (reduced dataset [1182 CS]).

	All		Breed				Caesarean section number			
	Total[a]									
	n	%	BB (n)	Non-BB (n)	OR[b]	95% CI[c]	1 (n)	2 (n)	≥3 (n)	p
Cow is recumbent upon arrival										
Yes	50	4.2	35	15	0.17	0.08–0.32	30	9	10[f]	NS
No	1132	95.8	1056	76			514	336	256[f]	
Excitation upon arrival										
Yes	116	9.8	112	4	2.49	NS[d]	46	37	32[f]	NS
No	1066	90.2	979	87			498	308	234[f]	
Dilation of soft birth canal										
Not complete	920	78.6	846	74	0.79	NS	424	274	201[f]	NS
Complete	251	21.4	235	16			118	68	65	
Status of calf										
Alive	1144	97.0	1056	88	1.09	NS	530	328	260[f]	NS
Dead	36	3.1	33	3			14	16	6	
Size of the foetus[e]										
Absolute	630	55.1	586	44	1.19	NS	248	196	174[f]	<0.001
Relative	514	44.9	472	42			278	136	86[f]	
Position of the calf										
Anterior	1069	91.2	988	81	1.17	NS	497	313	234[f]	NS
Posterior	103	8.8	94	9			44	28	29[f]	
Status of allantois sac										
Intact	248	21.2	235	13	1.67	NS	115	68	64[f]	NS
Not intact	920	78.8	842	78			425	272	197[f]	
Status of amnionic sac										
Intact	765	64.7	725	40	2.50	1.64–3.85	343	222	180[f]	NS
Not intact	417	35.3	366	51			201	123	86[f]	
Presence of foetal parts in birth canal										
Yes	256	34.3	226	30	0.58	0.35–0.96	133	78	45	NS
No	492	65.8	457	35			224	152	116	
Trail										
Yes	68	5.8	36	32	0.06	0.04–0.11	38	23	7	0.036
No	1114	94.3	1055	59			506	322	259[f]	
Epidural anesthesia										
Yes	642	54.3	581	61	0.56	0.36–0.88	307	171	151[f]	NS
No	540	45.7	510	30			237	174	115[f]	

a = Missing values not included
b = Odds Ratio (Belgian Blue versus non-Belgian Blue cows)
c = Confidence Interval
d = Non Significant
e = Estimated by the veterinarian
f = Data do not add up to total as some questionnaires were incomplete

Interval): 0.17 (0.08–0.32); Table 4)]. Dilation of the soft birth canal (vulva as well as cervix) was complete in nearly 80% of the cases. Three per cent of the calves had died before the start of the surgery (3.1% in BB compared to 3.4% in non-BB) and 8.8% were presented in posterior presentation (three of them in breech presentation). In more than one-fifth and in almost two-third of the cases, the allantoic and amniotic sacs were still intact before the operation, respectively. The amniotic sac was more likely to be intact [2.50 (1.64–3.85)] and foetal parts were less likely to be presented through the cervix [0.58 (0.35–0.96)] in BB cows. Attempts to extract the calf (trail traction) [0.06 (0.04–0.11)] and the need to administer epidural anaesthesia [0.56 (0.36–0.88)] were not as common in BB animals (Table 4). In cows which had undergone a CS before, the proportion of larger foeti was significantly higher and a trail traction was significantly less likely to have been performed (Table 4). The degree of experience of the veterinarian was not significantly associated with any of the pre-operative difficulties.

Skin scar tissue was more likely to be present in BB animals [3.03 (1.30–7.03); Table 5] and was more likely to lead to difficulties during the operation in cows that had undergone prior surgery. Significantly more abdominal wall muscular haemorrhage and skin scar tissue were present, and exteriorization of the uterus was more difficult in cows that had a prior CS ($p < 0.01$; Table 5). In almost one out of 10 CSs (8.5%), the surgeon was confronted with an overfilled or tympanic rumen when opening the abdomen (Table 5). In five animals, the rumen was accidentally incised and needed to be sutured before continuing surgery. Excessive tenesmus occurred in one-fifth of the cases; 4.2% without eventration of any organs while in 5.6% either the rumen, the intestines or the uterus prolapsed. Adhesions of the rumen with the abdominal wall were seen in almost 5%, whereas the uterus was adhered to the abdominal wall in 5.6% of the operations. Recumbency during surgery occurred in 2.3% of all cases (BB: 2.2%; non-BB: 4.6%; Table 5). In one-fifth of the CSs, the calf was lying with its back towards the abdominal incision (in the right horn; Table 5). In almost 10% of the cases, exteriorization of the uterus was not possible necessitating opening of the uterus in the abdomen (Table 5).

A ruptured uterine wall after extraction of the calf was seen in 6.3% of all surgeries (Table 5). Rupture of the broad ligament (*ligamenta lata*) without

Table 5. Overview of operative findings and difficulties, and their association with breed, caesarean section number and the degree of experience of the veterinarian [*reduced dataset* 1182 CSs)]

	Total[a]		Breed				Caesarean section number				Experience of veterinarian			
			BB	Non-BB			1	2	≥3		≤2	>2 to <5	≥5	
	n	%	n	n	OR	95% CI	n	n	n	p	n	n	n	p
Abdominal wall muscle haemorrhage														
Yes	378	32.0	356	22	1.52	NS	96	125	152[b]	<0.001				NA
No	804	68.0	735	69			448	220	114[b]					
Skin scar tissue														
Yes	198	16.8	192	6	3.03	1.30–7.03	3	66	125[b]	<0.001				NA
No	984	83.2	899	85			541	279	141[b]					
Position of the calf														
Leg to the wound	940	79.5	872	68	1.35	NS	417	285	217[b]	NS				NA
Back to the wound	242	20.5	219	23			127	60	49[b]					
Recumbency during CS														
Yes	27	2.3	23	4	0.47	NS	16	8	3	NS	12	7	8	NS
No	1155	97.7	1068	87			528	337	264[b]		446	212	497	
Overfilled rumen														
Yes	100	8.5	92	8	0.96	NS	44	29	25[b]	NS				NA
No	1082	91.5	999	83			500	316	241					
Exteriorization of the uterus possible														
Yes	1082	91.5	999	83	1.05	NS	512	328	224[b]	<0.001	425	195	462	NS
No	100	8.5	92	8			32	17	42[b]		33	24	43	
Incision of placentome														
Yes	141	11.9	128	13	0.80	NS	52	43	45[b]	0.010	58	33	50	NS
No	1041	88,1	963	78			492	302	221[b]		400	186	455	
Avulsion of a placentome														
Yes	26	2.2	24	2	1.00	NS	5	7	14	<0.001	15	6	5	0.045
No	1156	97.8	1067	89			539	338	252[b]		443	213	500	
Ruptured uterine wall														
Yes	74	6.3			NA		17	21	34[b]	<0.001	31	18	25	NS
No	1108	93.7					527	324	232[b]		427	201	480	
Haemorrhage in uterine wall														
Yes	61	5.2			NA		18	12	28[b]	<0.001	32	13	16	0.024
No	1121	94.8					526	333	238[b]		426	206	489	
Number of sutures in uterus														
One	999	84.5			NA		486	292	197[b]	<0.001	363	187	449	<0.001
Two	183	15.5					58	53	69[b]		95	32	56	

OR, odds ratio (Belgian Blue vs non-Belgian Blue cows); CI, confidence interval; NS, non-significant; BB, Belgian Blue; CS, caesarean section.
[a]Missing values not included.
[b]Data do not add up to total as some questionnaires were incomplete.

haemorrhage of the middle uterine artery (*arteria uterina*) occurred in three and with arterial haemorrhage in one of the 1275 operations, both fortunately without fatal outcome. During extraction of the calf, incision or avulsion of a placentome was common in cows that were operated on the second or subsequent time. While suturing the uterus, laceration of the suture line occurred in 2.7% of the CSs. Closure of the uterus by a double-layer suture was needed more frequently in cows that had multiple CS (Table 5). Less experienced (≤2 years) veterinarians encountered more pulling off of placentomes and haemorrhage of the uterine wall. Highly experienced (≥5 years) veterinarians closed the uterus using one suture layer rather than using two layers (Table 5).

Multivariable, multilevel analyses

Mild difficulties were nearly two-times as likely [OR: 1.89 (1.36–2.61)] to be present in a second CS animal and 3.6-times [OR: 3.62 (2.48–5.28)] as likely in older cows (≥3 CS) compared with an animal undergoing its first CS, respectively (Table 6).

Surgeons operating on cows of the BB breed were less likely to encounter severe difficulties compared with those operating on non-BB animals in the model adjusting for number of CS [OR: 0.47 (0.27–0.81)]. In second and higher parity animals, the veterinarian was 2.4 times (1.70–3.28) and 6.0 times (4.12–8.86) more likely to be confronted with a SD, respectively, compared with a primiparous animal. Highly experienced veterinarians (≥5 years) were less likely to encounter difficulties during the operation than less experienced surgeons [OR: 0.36 (0.46–0.87); Table 6)].

Discussion

This study is to our knowledge the first one studying a large number of difficulties during rather than after the CS. A number of significant univariable associations (not corrected for potential risk factors or confounders) between breed, number of CS and degree of veterinary experience with different pre-operative and operative findings and difficulties were identified. Multivariable models showed that BB cows had significantly fewer severe difficulties during CS in comparison with non-BB cows, whereas this breed effect could not be demonstrated for mild problems.

In Belgium, thorough selection towards muscular hypertrophy in the BB breed resulted in cows being unable to calve *per vaginam* and CSs are performed routinely. As a result, CSs are performed by highly experienced veterinarians who typically carry out between 500 and 1000 CSs each year. Additionally, BB owners are well skilled in detecting parturition at an early stage. As the promodori in this breed are not explicit, the temperature method is commonly used and the animals are closely observed every 2 h, even at night. The early detection of parturition is confirmed in this study by the fact that less animals of the BB breed were recumbent at the time the veterinarian arrived at the farm, suggesting that the majority of the BB animals were in labour for a shorter period of time before the start of the operation. Also, in BB cows the amniotic sac was intact more often and foetal parts were not present in the birth canal upon vaginal examination. Epidural anaesthesia was used less frequently in BB animals, probably because of the absence of severe tenesmus due to the relatively early stage of parturition in which the surgery was done in these animals. Because some veterinarians tended to administer epidural anaesthesia routinely, the difference between BB and non-BB cows would have been larger if an epidural anaesthesia was only administered to straining animals.

Breed was chosen as a risk factor to see whether it was associated with the occurrence of difficulties during CS, although we did not expect breed differences. Rather breed reflected an elective (BB) vs non-elective (non-BB) CS. On the other hand, as a lot of farmers own one or more BB animals or are familiar with the breed, they are used to call for assistance at parturition in an early stage and ask for a CS even in the non-BB herds. Then again, some farmers and veterinarians will wait a little longer to see whether a normal calving is possible.

In this study, nearly one out of three CSs was accompanied by a severe difficulty reported by the veterinarian. Still, only three out of the 1275 CSs (0.2%) had a fatal outcome. The average death rate within a week after CS in dairy cows, typically operated at a very late stage, is reported to vary between 1.5% (Barkema et al. 1992) and 14% (Bouchard et al. 1994). Other studies performed in non-BB animals also showed lower

Table 6. Final multilevel logistic regression models describing the significant risk factors associated with the occurrence of mild [(350/877 (816 cows)] and severe [398/926 (866 cows)] difficulties during caesarean section performed between January 2005 and June 2006

		Breed					Number of caesarean section						Experience of veterinarian					
Difficulty		β	SE	OR	95% CI	p		β	SE	OR	95% CI	p		β	SE	OR	95% CI	p
Mild	Non-BB[a]					NS	1[a]					<0.001	Low[a,b]					NS[c]
	BB						2	0.64	0.17	1.89	1.36–2.61		Medium					
							≥3	1.29	0.19	3.62	2.48–5.28		High					
Severe	Non-BB[a]					<0.010	1[a]					<0.001	Low[a,b]					<0.010[d]
	BB	−0.76	0.28	0.47	0.27–0.81		2	0.86	0.17	2.36	1.70–3.28		Medium	0.15	0.20	1.16	0.79–1.72	
							≥ 3	1.80	0.20	6.04	4.12–8.86		High	−0.45	0.16	0.36	0.46–0.87	

BB, Belgian Blue; SE, standard error; OR, odds ratio (= $\exp^{\beta}$); CI, confidence interval.
[a]Reference category.
[b]Low: ≤2 years, medium: >2 to <5 years, high: ≥5 years of experience.
[c]Non-significant, also not in the univariable analyses.
[d]Significancy for low experience compared with high experience not for low experience compared with medium experience.

cow survival in dairy cattle (Sloss and Dufty 1977; Roberts 1986; Vandeplassche 1988; Arthur et al. 1989; Cattell and Dobson 1990). Belgian Blue cows typically are protected from suffering from a severe difficulty during surgery because surgery in these cows is performed at an early stage and due to the fact that farmers breeding BB are highly trained in detecting early parturition. As a result of the latter, the animal is not straining yet, the incision of the abdominal wall is easier, the exteriorization will be less complicated and there is lesser risk of incision in the wrong place of the uterus. Nevertheless, we are fully aware that the post-operative outcome in our study is limited for comparison with other study as the emphasis of this study was on difficulties before and during the CS.

In BB cows with an increasing number of previous CSs, an attempt to extract the calf was performed less often. Because of the high economic value of the double-muscled calves and the relatively low charge for a CS, Belgian farmers are not willing to take risks and usually expect their veterinarian to perform a CS in case of any doubt to deliver a live calf. For that same reason, veterinarians will hardly ever carry out a trail traction when facing a calving BB cow which had previously undergone a CS. Omitting a trail traction has in this typical situation several advantages, such as diminished to no tenesmus during surgery, a lower probability of recumbency during the operation and a reduced contamination risk of the uterus. The latter is important to avoid complications after surgery, such as peritonitis or wound infection (Mijten et al. 1996).

In animals which had previously calved by CS, more difficulties were encountered during the operation. Belgian Blue cows were more likely to have skin scar tissue than non-BB cows. The occurrence of excessive skin scar tissue and abdominal wall muscular haemorrhage also increased as a result of the increase in the number of CSs. As BB cows generally have 2–3 CS in a life time, one would expect more difficulties in that breed. Still, lower prevalence of severe problems was seen in the BB breed compared with non-BB animals when adjusting for the number of CSs. The combination of operating at an early stage during parturition and the operation being performed by very experienced veterinarians is probably the reason for the excellent results in favour of the BB breed. The surgeon's technical skills are mentioned to be among the best preventive factors against difficulties such as problems with exteriorization of the uterus (Mijten et al. 1997).

One of the most common intra-operative complications is difficulties with exteriorization of the uterus. Of the three risk factors analysed, only the number of CSs had an association with exteriorization difficulties. In the study of Hoeben et al. (1997) in BB animals, the surgeon had trouble with the exteriorization in 26.4% of all CSs and in 5.8% of the cases, it was completely impossible to exteriorize the uterus. Increased parity, increased uterine contractions, posterior presentations and adhesions between the uterus and the abdominal wall were progressively more significantly associated with the degree of difficulty to exteriorize the uterus.

We realize that a difference in perception of difficulties between inexperienced and highly experienced veterinarians may have influenced our results. More experienced veterinarians (≥5 years) might have underreported difficulties, whereas the opposite could be true for less experienced (≤2 years) surgeons. However, there was also variation within the experience categories of the veterinarians. But, in general, it is accepted that the experienced veterinarians encounter fewer difficulties during surgical interventions. Besides that, we believe that the questionnaire minimized the risk of bias as it consisted only of closed-ended questions (yes/no or categories).

Conclusion

During a CS in the bovine, mild and/or severe operative difficulties can be expected. As nearly all BB calves are delivered by CS, farmers and veterinarians should be aware of factors that influence the risk of encountering difficulties, such as multiple CS, as this will help them to minimize the occurrence of problematic situations. Performing a CS at an early stage during parturition is a standard procedure in BB cows which significantly reduces the odds of encountering problems before and during surgery. Having had a prior CS is associated with an increased risk for mild and severe difficulties. Highly experienced vets are less frequently confronted with severe difficulties, although they may also underreport difficulties in comparison with less experienced colleagues. Future studies should investigate post-operative complications in relation to the difficulties encountered during surgery.

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Author contributions

Iris Kolkman wrote the article and did most of the statistics and the experiment. Sarne De Vliegher did a part of the statistics and helped with writing the article. Boudewijn Lindenbergh did the experiment. Geert Opsomer and Aart De Kruif read and commented on the article.

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Author's address (for correspondence): Iris Kolkman, Faculty of Veterinary Medicine, Department of Reproduction, Obstetrics and Herd Health, Ghent University, Salisburylaan 133, B-9820 Merelbeke, Belgium. E-mail: iris.kolkman@ugent.be; iris.kolkman@kahosl.be