Incidence of uterine torsions in dairy cattle in five veterinary practices in the Netherlands

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ABSTRACT

Uterine torsions are an important complication during parturition in cattle. In case of a uterine torsion, the uterus is twisted around its longitudinal axis, in such a way that the foetus cannot be expelled. This, unfortunately, leads to an increase in dam and calve mortality, which is economically unfavourable. Several studies have been done to investigate the incidence of uterine torsions as part of the total number of cases of dystocia. However, the incidence of uterine torsions has not yet been investigated in the Netherlands. The aim of this study was, therefore, 1) to determine the incidence of uterine torsions of dairy cattle in five veterinary practices in the Netherlands and to make an estimation of the total incidence of uterine torsions in the Netherlands. 2) To look for possible risk factors associated with the incidence of these torsions in literature. Risk factors such as season, age and parity will be examined with data of the practice management system (PMS) of one practice; to see if there is a relation between these factors and the incidence of uterine torsions. Seasonality of uterine torsions will also be compared with all the other cases of dystocia, to see if there is a significant seasonal predisposition of uterine torsions. A total of 3049 cases of dystocia occurring in 2015 and 2016 are incorporated in this study. It has been found that uterine torsions make up 24.0% of all cases of dystocia. The incidence of uterine torsions increased over the years 2015 and 2016; from 21,3% to 26.6%, respectively. The risk for a cow to endure a uterine torsion was 0.360% in 2015, whereas cows had a risk of 0.438% to have a uterine torsion in 2016. The number of uterine torsions fluctuates between different practices and farms as well. In this study, a significant higher incidence of uterine torsions has been found in autumn, compared to spring if all the other cases of dystocia were used as a control. However, if all the other lactating cows at a farm with a uterine torsion were used as a control, there was a significant higher incidence in autumn when compared to winter and summer. Age and parity seem not to have a significant influence on the incidence of uterine torsions.

Key words: uterine torsion, bovine, cow, incidence, Netherlands.

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INTRODUCTION

Birth is an extremely important process in the dairy industry, since annual parturition is necessary for milk-production. With almost 1.8 million lactating cows in the Netherlands in the year 2016, it is clear that there are many possible birth-complications, also known as dystocia (1). There are several causes for dystocia. For example, fetal mispositioning, fetal death, feto-pelvic disproportion, failure of expulsive forces and uterine torsions (2). The primary causes of dystocia differ in primiparae and pluriparae animals (3).

In this research study, the uterine torsion as cause of dystocia in cattle will be discussed. Uterine torsions are especially apparent during the first stage of parturition (4). In case of a uterine torsion, the uterus is twisted around its longitudinal axis in such a way that the foetus cannot be expelled (5–8). The origin of a uterine torsions is still not fully clear, but it is expected that the unfavourable anatomy of the uterus has enormous influence on the appearance of a uterine torsion (5,9–12). Different risk factors for uterine torsions have been proposed, for example: breed (7,12–15), age and parity of the dam (7,12–14), as well as foetal gender (7,10,14). The reported incidences of uterine torsions vary over the past years, ranging from 3.0% to even 24.1% (2,7,10,11,13,16–19)

Because wide varying incidences are stated over the past years, it is unclear what the real incidence of uterine torsions is. Moreover, incidence studies have not been performed in the Netherlands yet. For the different veterinary practices and the study veterinary medicine in the Netherlands, it is important to know how often uterine torsions are a complication during parturition. Therefore, the aim of this study is 1) to determine the incidence of uterine torsions of dairy cattle in five veterinary practices in the Netherlands and to make an estimation of the total incidence of uterine torsions in the Netherlands. 2) To look for possible risk factors associated with the incidence of these torsions in literature. Risk factors as season, age and parity will be examined with data of the practice management system (PMS) of one practice, to see if there is a relation with the incidence of uterine torsions.

LITERATURE STUDY

DYSTOCIA IN COWS

Birth and the first hours after parturition are critical the recently born calve. When parturition is not performed easily, we speak of dystocia. The word dystocia comes from the Greek words dys and tokos. Since dys means difficult and

Table 1: Causes and incidence of dystocia in 119 Holstein-Friesian cows living at the pasture, from: Faria and Simões (2015) (2).

Cause of dystocia	Number of animals	Incidence
Uterine torsion	29	24.3%
Fetal malposture	23	19.3%
Fetal posterior presentation	16	13.4%
Incomplete cervical dilatation	14	11.8%
Feto-pelvic disproportion	12	10.1%
Fetal death	6	5.0%
Secondary uterine inertia	5	4.2%
Failure of abdominal expulsive forces	4	3.4%
Primary uterine inertia	4	3.4%
Fetal monsters	3	2.5%
Fetal lateral position	2	1.7%
Fetal transversal presentation	1	0.8%

tokos means birth, dystocia may be defined as a calving difficulty (20). Dystocia can be classified as having a maternal or fetal origin. However, it can be difficult to categorize the primary cause of dystocia to be either completely maternal or completely fetal. It is, therefore, easier to divide dystocia in three different classes; which are: an insufficient expulsive force, an abnormal birth canal or an inappropriate size and/or position of the foetus (4).

As mentioned, there are a lot of different types of dystocia. The primary cause of dystocia differs in primiparae and pluriparae cows. Disproportion of fetal size and pelvic outlet is the major cause of dystocia in younger cows. Abnormal fetal position is the most common origin of dystocia in pluriparae animals. Fetal malpositioning accounts for 20-40% of the dystocia cases. About 10% of all dystocia cases are due to uterine inertia, in which the cervix is dilated but the myometrial contractions are too weak to push out the foetus (3). This is seen more often in pluriparae animals. For example, in animals with hypocalcaemia, debility and pre-term calving (21). Other complications during parturition are vulval or cervical stenosis and uterine torsions (3). The incidence of the different types of dystocia were measured in 119 Holstein-Friesian cows living at the pasture. Results are given in table 1 (2). However, the circumstances in which these pastured cows live, may not be fully representative for the conditions in which Dutch dairy cows live.

In heifers, the incidence of dystocia is higher than in older cows. *Funnel et al.* describes a 17.3% incidence of dystocia in heifers, this decreases to 4.7% in second calf cows. The incidence of dystocia at different parities is represented in table 2 (20). This trend is also seen in the percentage of assistance required during calving. *Lombard et al.* monitored that 51.2% calves born to heifers needed assistance during the parturition; compared to 29.4% in multiparous animals (22). Other data even implies that 66.5% of first calvings require an assisted delivery; compared to 23.1% and 14.3% in respectively second and third calvings (4)

Besides the parity and age of the dam at calving, there are some other factors that influence the incidence of dystocia. Calf sex and birth weight of the calf are important factors as well. It has been found that male calves are leading to more difficult calvings, when compared to female calves (4). In a study including 7788 parturitions, 21.6% was classified as severe dystocia, where assistance of two or more people or a surgical procedure was needed. 13.4% of these severe cases included a male calve, compared to a smaller percentage of 8.2% which included a female calve (22). This study found that a higher birth weight leads to an increase in dystocia. Of calves with a birth weight under 20 kilogrammes 88.7% of the male calves and 95.1% of the female calves are born without any assistance. This decreases to 40.0% and 58.9% unassisted parturitions in male and female calves, respectively, when weight is over 40 kilogrammes. Moreover, in this group of over 40 kilogrammes, it is seen that the incidence of severe dystocia rises to 19.4% for male calves and 16.4% for female calves. A big difference can be seen, when compared to smaller calves of 20 to 40 kilogrammes, in which the incidence of severe dystocia ranges from 0% to 7.7% (22). Factors as gestation period, breed of the dam and breed of the sire are also important: both factors are strongly associated with the birth weight of the calf. Also, dystocia is more common in twins, than in single calves. This may be caused by the lesser amount of space left in the uterus with twins (4).

There are numerous possible consequences caused by dystocia. For example, an increase in stillbirth and morbidity in the neonatal calf (4). Heifer calves that endure severe dystocia during parturition have greater odds of several complications. Lombard et al. found an odds ratio of 20.7 for stillbirth, an odds ratio of 1.7 for respiratory disease and an odds ratio of 1.3 for digestive disease. Besides consequences for the heifer calf, an increase in heifer mortality was found as well, with an odds ratio of 6.7 (22). Moreover, dystocia may result in reduced productivity, reduced fertility and an increase in puerperal diseases in the dam (4). The effects on productivity are most evident early in the lactation of high yielding cows (3). The effects on fertility after uterine torsions are mostly seen in pluriparae cows or cows that had complications during the puerperium. The reduced fertility may be caused by delayed uterine involution and delayed luteal activity after parturition. Abnormal progesterone levels are also leading to a delayed onset of oestrus (3).

Table 2: The incidence of dystocia by age measured by 29.970 full-term births. From: Funnel and Hilton (2016) (20).

Cow age	**Risk**	**95% confidence interval**
Heifer (1rst calf)	17.3%	10.9-26.4
3-year-old (2nd calf)	4.7%	2.8-7.9
4-year-old (3rd calf)	3.7%	2.2-6.3
Mature cow (5 to 10-year-old)	2.9%	1.7-4.9
Old cow (> 10-year-old)	3.2%	1.9-5.6

DESCRIPTION OF A UTERINE TORSION

Uterine torsions are described in a lot of different domestic species. Bovine species, however have the highest incidence of this complication. The complication is mostly seen in dairy cows and is only rarely reported in beef cows (4,7). The torsions are also described in buffaloes, in which they cause approximately 52% to 70% of all maternal dystocias at the end of gestation (23). Uterine torsions are also described in the pregnant bitch and the queen, however this is mostly a complication of an enlarged uterus due to pyometra or mucometra (8).

A uterine torsion is a complication that mostly occurs during the late first stage or early second stage of labour. The first stage refers to the preparation of the birth canal for expulsion of the foetus. The cervix dilatates, the myometrial contractions start and the foetus gets in position for expulsion during this stage. During the second stage, the expulsion of the foetus begins (5). Most cases of uterine torsions are presented close to parturition. Whereas *Frazer et al.* states that 81% of the cows is at term; *Erteld et al.* describes 83.7% to 100% of all uterine torsions are first noticed during labour. It needs to be noted that there are also a few cases of uterine torsions described in the post-partum period (14). A uterine torsion is more common during the first stage of labour, because a degree of cervical dilation is noted close to the moment of detorsion, meaning the cow has entered the first-stage of labour (7).

In case of a uterine torsion, the uterus and its uterus horns are rotated in a way in which the foetus cannot be expelled (5–7). The uterus is twisted around its longitudinal axis, stretching the mesometrium (7,8). When the torsion is over 45˚ it will result in dystocia, per *Frazer et al*. However, if the uterus is rotated for only 45˚, there is a chance that the uterus corrects itself spontaneously (7). It is, therefore, questionable if the margin of 45˚ is a good one. *Erteld et al.* declares that uterine torsions under 180˚ are quite uncommon (14). At the University of Utrecht, only torsions over 180˚ are mentioned as a uterine torsion (24).

In most cases, the gravid horn rotates over the non-pregnant horn, which will result in a counter-clockwise torsion in case of a right horn pregnancy. The same author reports an incidence of 63% of counter-clockwise or left-sided twists (7). In a study with 55 field cases of uterine torsions, an incidence of 62% for counter-clockwise torsions was recorded. However, due to the small sample population, this was not statistically significant (11). Because of the higher incidence of counter-clockwise torsions, it is expected that there is an association with right horn pregnancies. This is confirmed by the fact that 60% of all pregnancies are concepted in the right uterus horn (7). *Mock et al.* even describes a 96.2% incidence of counter-clockwise torsions, which cannot be explained by the higher amount of right horn pregnancies (13). It is striking that in buffaloes, most of the uterine torsions are right sided, which implies a clockwise torsion. This is due to a difference in the broad ligaments in buffaloes: a muscular fold in the right broad ligament of buffaloes is missing. As well as the presence of the rumen on the left side, which may contribute to the higher incidence of right-sided uterine torsions (23).

As mentioned, a torsion of at least 45˚ leads to problems during parturition. The most common torsions are 90˚ to 180˚, these make up 20% of all reported cases. This is because these uterine torsions are partly corrected by the farmer itself. *Frazer et al.* found most uterine torsions to range from 180˚ to 270˚. In total, 57% of the 164 cases described in his study were in this range. Between 270˚ and 360˚, there was an incidence of 22% and 9.2% of the torsions was greater than 360˚ (7). Per *Frazer et al.,* the highest incidence of torsions is ranging from 180˚ to 270˚; which is in accordance with results of *Erteld et al* (14). Looking at all these different grades of uterine torsions, there is also a difference in the involvement of the vagina and cervix. It is most common that the torsion extends beyond the cervix, which leads to the involvement of the vagina in the torsion. This form of uterine torsions is called post-cervical (7). The involvement of the vagina can be diagnosed by the presence of vaginal folds, whereas these folds would be absent in pre-cervical torsion (11). Pre-cervical torsions arise during the antepartum period, when the cervix is still closed and they do not involve the vagina (14). It is speculated that the arising of a post-cervical torsion is only possible when a cow is intra partum (14). About 2/3 of the cases described by *Frazer et al.* had an involvement of the vagina (7). *Aubry et al.* describes a vaginal involvement of 63%. However, this was only numerical and not statically significant (11).

A uterine torsion can be diagnosed by vaginal palpation, when the torsion is less than 240˚ and post-cervical. It is also possible to diagnose a uterine torsion by rectal examination, in which the direction of the broad ligaments is important (5,9,10,12,25). See figure 1 for a schematic visualisation of the broad ligaments in case of a uterine torsion. Some clinical signs may be apparent, as mentioned by *Frazer et al.,* but are not always visible (7). Correction methods as per-vaginal rotation of the foetus, rolling of the cow and flank laparotomy can be performed as a therapy (5,7,9–12,26,27). It needs to be noted that the degree of torsion, location of the torsion and the cervical dilatation are critical factors that influence the choice for a specific therapy. However, it is beyond the scope of this article to discuss diagnosis and therapy in more detail.

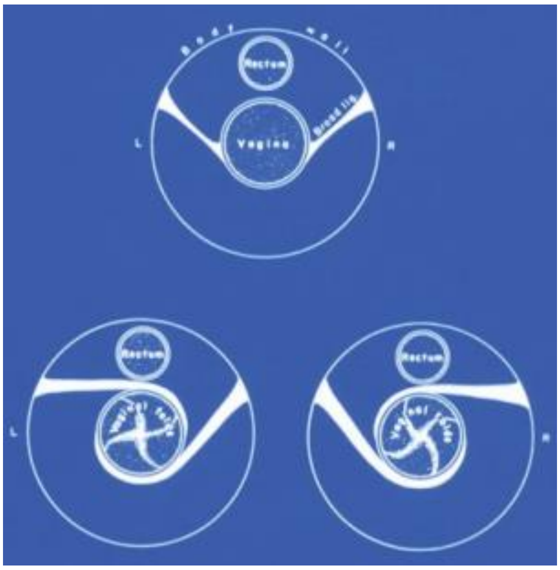

Figure 1: The relative position of the broad ligaments in case of a uterine torsion. On the left lower corner, a clockwise (right) uterine torsion of 180 is visible. On the right lower corner, a counter-clockwise (left) uterine torsion is diagrammed. From Drost et al., 2014 (9).

Even after a correct diagnose and therapy, there are still a lot of consequences for the calve and the dam, which will be discussed briefly. After a uterine torsion, there is often a failed cervical dilatation, which prohibits the normal birth-process (11,26). The prolonged parturition leads to reduced foetal survival, caused by vascular compromising and sometimes the loss of uterine fluids (2,5,7,19,26). Also, the dam has reduced survival chance due to bleeding, thrombosing and necrotizing of the uterine vessels and uterus itself. This can possibly lead to a uterine rupture (7,28). There is a risk for retention of the fetal membranes, which eventually can lead to metritis (7,13,26). Some studies also found that cows that have endured a uterine torsion had significantly worse fertility (12,13,19,26).

THE BOVINE UTERUS

To make clear why bovines are more likely to have a uterine torsion when compared to other domestic animals, it is necessary to know more about the normal physiology of the bovine uterus. The female reproductive track lies directly under the rectum and these structures are partly divided by the rectogenital pouch (29). The complete reproductive track is stabilised by the broad ligament, that is constituted by the mesovarium, the mesosalpinx and the mesometrium. The mesometrium is the largest part of the broad ligament and stabilises the body of the uterus (29,30). The broad ligament is formed by the retroperitoneal development of the reproductive tract and the rectum. Eventually, a double layer of peritoneum forms with the reproductive tract lying in it (29).

The uterine body is quite small in cows and the horns are attached to this part of the uterus. The horns are of moderate length in cows (29–31). In situ, the uterus body lies between the rectum and the bladder with two ventral curving uterine horns. Where the horns diverge, there is an intercornual ligament (30). The uterus of bovines is unstable, especially during the gestation, due to the attachment of the broad ligaments. This because the ligaments are attached to the ventral lesser curvature of the uterus, but are supported by the dorsolateral body wall (5,9–11). Moreover, the horns of the uterus lie unsupported in the body cavity (12). During advanced pregnancy, the uterus gets bigger and is positioned beyond the stable point of attachment. This is also due to the relatively small increase in length of the broad ligaments (12). Eventually, the uterus rests on the abdominal floor and is only supported by the rumen, viscera and abdominal wall. It is, therefore, easy for the gravid uterus to displace and twist during a sudden movement (11).

If we look at the different bovine species, there are also big differences in incidence. The species Bos Taurus, which includes the normal dairy cow, has a much higher incidence of uterine torsions when compared to the species Bos Indicus. This is due to the more dorsal attachment of the broad ligaments in the anterior part of the uterus in the Bos Indicus species. Only a small part of the broad ligament is attached more ventrolateral to the uterus. This makes the uterus more stable in Bos indicus species. In other bovine species, the uterus is only supported by the broad ligaments at the ventrolateral side of the uterus; leading to much more movability (12). As mentioned in the first paragraph, the incidence of uterine torsions is higher in buffaloes, than it is in cows. *Purohit et al.* describes an incidence ranging from 52% to 70%. This is partly due to the relatively long broad ligaments in buffaloes, which allow much more movement of the gravid uterus. It is also speculated that the deep abdomen, in combination with the weaker muscles in the broad ligament, as mentioned by Ghuman, as well as the movement habits increase the incidence of uterine torsions in buffaloes (12,23).

In comparison to other animals, there are big differences in the physiology of the broad ligaments. For example, the broad ligaments of the mare are attached to the lateral side of the uterine body. There are also parts of the ligament connected to the dorsal border of the uterine horns (32). This makes it so that the uterus of the mare lies more stable in the body cavity and therefore results in a lower incidence of uterine torsions in mares (32,33). Uterine torsion in the bitch and the queen are very uncommon (34). Cases are present in which a polypoid mass moves the uterus more ventral behind the point of the supporting ligaments. In these cases, the stable positioning of the uterus is influenced, eventually leading to a uterine torsion. The lower incidence is because of the structure of the uterus (35).

ETHOLOGY OF A UTERINE TORSION

Much is still unclear about the ethology of a uterine torsion, but several theories and factors are proposed. The most predisposing factor for a uterine torsion is, without a doubt, the unfavourable anatomy of the bovine uterus, as discussed above (5,7,14). Another risk increasing factor including the uterus is a relatively low amount of amniotic fluid, which enhances the effects of the fetal movement (12). During the late first stage of parturition, the foetus takes in his expulsion position. This is due to the onset of increasing frequency and amplitude of the uterine contractions. Eventually, this will lead to fetal movement inside the uterus and a bigger risk for the onset of a uterine torsion (5). It is stated that uterine instability on his own can only induce torsions up to 180˚, whereas in combination with extreme fetal movement, torsions up to 360˚ are possible (5). Also, when the uterus lies outside the supraomental bursa, it is more vulnerable for movement, because it is little fixated. In 78% of the caesarean sections performed because of a uterine torsion, the uterus was found outside the supraomental bursa (14).

The increase in fetal movement and the anatomy of the bovine uterus are not the only factors leading to a torsion. The movement of the dam while standing up, is another factor influencing the stability of the uterus (5,7,14). *Noakes et al.* describes that when a cow is lying down in a confined space, she first moves her weight to both knees. Then she moves head and body up in a way that the hind legs can be stretched. In this way, the uterus is extended in the most vertical way and it is, therefore, easy to rotate on its axis. Even though a cow only stands in this position for a short period of time, it is possible for the uterus to strangulate (5). *Erteld et al.* describes that sole sore and pain in the knees and hips increase the time that a cow stands in this unfavourable position. Also, a small stand width seems to increase the risk for a uterine torsion (14). The anatomy of the bovine uterus is a clear risk factor for uterine torsions. However, it is unclear if and how much influence other factors have on the appearance of uterine torsions.

RISK FACTORS FOR UTERINE TORSIONS

There are several risk factors for uterine torsions. First, the factors that are associated with the dam and classified as non-fetal will be discussed. These are seasonal influences, geographical location, type of housing, breed, age, parity and stage of gestation. Later, the factors associated with the calf will be described. These are classified as fetal factors. Factors in this category are fetal gender, fetal weight, fetal presentation and twin or single pregnancies. Especially fetal weight is an important factor in the development of a uterine torsion (7). After each two categories, a small summary and conclusion will be given.

NON-FETAL FACTORS: SEASON OF THE YEAR

It is sometimes suggested that there is an influence of season on the appearance of uterine torsions. However, studies combining data of 24 American veterinary clinics, found no month in which there was a significant higher incidence of uterine torsions. During this study, it became clear that almost 35% of the cases were presented during the spring, with the highest incidence in March and April, however this was not significant when compared to the calving pattern in the control group (7). *Aubry et al.* found the highest incidence during the summer and the winter and this was significant (11). A retrospective study of Brown Swiss cattle found a high incidence of 50% during the months August to November. Though, this was probably due to the seasonal calving pattern, with peaks from August to November, as the control population had a comparable calving distribution (13). In another study, the effects of an outbreak of foot-and-mouth disease on the incidence of uterine torsions were measured. This research describes that uterine torsions are moderately to strongly seasonal. Also, this study found that the incidence of torsions during the month July increased extremely after the outbreak of foot-and-mouth disease. It was 8.7% before the outbreak and increased to 13.1% after the outbreak. However, this was not significant and the author did not give an explanation for this (18).

NON-FETAL FACTORS: GEOGRAPHICAL LOCATION

Frazer et al. documented different incidences of uterine torsions over different continents. In Australia, the incidence was only 1% to 3% of the total number of dystocia. The incidence in Europa was slightly higher and the incidence in North America is even higher. It is expected that this due to the differences in diet over the world. The cows in Australia mostly live on the pasture and have less or none concentrate in their diet when compared to cows in Europa or America (7). It is stated that a large concentration of concentrate in the diet leads to a smaller rumen volume, which, in turn, leads to more space in the abdominal cavity. Therefore, the uterus is positioned less stable in the abdomen (36).

Several studies also see an association with more hilly or alpine regions and the incidence of uterine torsions (13,14,18). This is an effect of the upwards and downwards movement on the hills, which will lead to more movement of the uterus. *Ghuman* describes that this effect only leads to a minor difference in the incidence of uterine torsions (12). However, incidences of 13.8% are described in Switzerland, which was explained by the hilly areas in the Alps or the breed of cows (14).

NON-FETAL FACTORS: TYPE OF HOUSING

Different studies found an effect of the housing on the incidence of uterine torsions. It is contrary that some studies describe a higher incidence in pastured cattle, whereas others found stalled animals as having an increased risk. *Faria et al.* found a higher incidence of uterine torsions in cows living at the pasture (2). *Erteld et al.* describes that there is a higher incidence in pastured cows as well. This may be due to the more excessive movement during pasturing (14).

However, it is also stated that confined animals are more prone to uterine torsions. This is because they have less exercise, which eventually leads to weakness of the abdominal muscles (12). Studies also investigated the influence of housing in a tie-stall, loose individual housing or loose group housing on the incidence of uterine torsions. It was found that cows that were individually housed during parturition were at lower risk for uterine torsions when compared to cows in a tie-stall. Cows experiencing group housing were more at risk for uterine torsions compared to cows in a tie-stall (11). It is speculated that the higher incidence of uterine torsions in cows experiencing group housing comes from the higher risk of being bumped on the side by another cow (12).

NON-FETAL FACTORS: BREED

If we look at the different breeds of cattle, there are some breeds with an increased risk for uterine torsions. As mentioned, the risk for a uterine torsion is much higher in the species Bos Taurus, when compared to the species Bos Indicus. This is an effect of the anatomy of the broad ligaments, which is more favourable in the Bos Indicus species (12). The incidence of uterine torsions is also higher in buffaloes, than it is in the species Bos Taurus (12,23).

The influence on the incidence of uterine torsions within different breeds within the species Bos Taurus has been investigated. A study analysed 790 cases of uterine torsions and found that Holstein and Charolais cattle were significantly more presented with a uterine torsion. Moreover, it is determined that Brown Swiss cattle are the highest risk breed; Brown Swiss cattle have a 2.61 increased risk of having a uterine torsion, when compared to Holstein cattle (7). The fact that Brown Swiss cows are more at risk is also described by *Mock et al., Erteld et al.* and *Beltman* (13–15). It is thought that this is an effect of the more capacious abdominal cavity of Brown Swiss cattle (12). Of all cattle breeds, Hereford, Jersey and Angus cows were found to be significantly less at risk for uterine torsions (7). This is possible due to the smaller body-frame and the smaller calves of these breeds (14). Close after the outbreak of foot-and-mouth disease in the UK, an increase in the incidence of uterine torsions was seen. It is expected that this is due to the repopulation with Holstein cattle that had a taller posture and an increased body depth. This makes it clear that not only breed, but also body posture within a specific breed has influence on the incidence of uterine torsions (15).

NON-FETAL FACTORS: AGE AND PARITY OF THE DAM

The age and parity of the dam are thought to be correlated with the risk of a uterine torsion. Studies including data of 24 North American veterinary hospitals, make clear that cows with an age ranging from seven to ten years old are at a lower risk, when compared to cows with an age ranging from two to four years old. In this study it was expected that all two year old cows were primiparous (7). Looking at parity or lactation number, *Aubry et al.* found most uterine torsions at cows with a first or second lactation. However, this was not statistically significant (11). This is in agreement with the results of *Frazer et al.*

On the other hand, in another study, there was a higher incidence of uterine torsions in multiparous animals. 32% of all multiparous cows with dystocia were presented with a uterine torsion, compared to only 10% in primiparous animals (11). *Mock et al.* also describes a higher incidence of uterine torsions in multiparous animals. Of all cases of uterine torsions, 74.2% was in a multiparous cows (13). The higher incidence in multiparous animals is thought to be caused by the loosening of the pelvic ligaments, broad ligaments and uterine tissue; also, the larger abdominal cavity may increase the risk of a uterine torsion (12). The lower incidence in primiparous animals is probably because there are other forms of dystocia that are more common in younger animals (14).

NON-FETAL FACTORS: STAGE OF GESTATION

According to *Frazer et al.,* the stage of gestation is also an important factor. Of the 160 cases observed, 81% of the cows was presented seven days prior or after the due date. 8% of the other cases was more than seven days prior expected due date and 11% was presented over seven days after expected due date (7). *Mock et al.* also implies that uterine torsions were seen mostly at term (13). This may be an effect of the high progesterone and low oestradiol levels close to parturition. Especially the high progesterone level makes the uterus more flaccid and increases the risk for a uterine torsion (12). Likewise, the relative decrease of amnion fluid in the uterus close to due date makes that little movement of the foetus leads to more instability of the uterus (14). It is also suggested that the foetus will adapt to maternal movement with strong reflexes due to the lower amount of amnion fluid (12).

CONCLUSION: NON-FETAL FACTORS

Results regarding the influence of season on the incidence of uterine torsions are varying. Some studies did not find a influence at all (7,13). Others did find a significant influence of season (11,18). It is, therefore, interesting what this research study will find on the influence of season. Following the results of several studies, there is an influence of geographical location on the incidence of uterine torsions (7,12–14,18). However, these results are possibly varying due to different study designs. The type of housing has also been investigated, but results are contradictory. It is proposed that pastured animals are at higher risk for uterine torsions (2,14). On the other hand, it is also stated that confined animals are more at risk (12). The outcomes of these studies may vary due to the different circumstances in which the cows live; *i.e.* climate and cow-density. All studies regarding cow-breed, found the same correlation between breed and the risk for a uterine torsion. Especially Brown Swiss cows seem to have an increased risk for uterine torsions (7,13–15). Outcomes regarding age and parity are varying. One states that multiparous cows with an age of seven to ten are less at risk for a uterine torsions (7). Also, *Aubry et al.* found more first and second parity cows that endured a uterine torsions (11). Others, state that especially primiparous cows are at a lower risk for a uterine torsion (11–13). It is clear that most cases of uterine torsions are close to due date (7,13).

FETAL FACTORS: FETAL GENDER

A strong association between uterine torsions and fetal gender is sometimes suggested in literature. Of the 90 cases described by *Frazer et al.,* there was a significantly higher percentage of calves that was male (7). An analysis of *Lyons et al.* did not find a similar distribution. In this study, 49% of all calves was male and 51% was female. However, it became clear that after correction of the torsion, there was more assistance required due to further obstetrical problems in male calves. This was partly due to the greater size of the male calves (10). In the meta-analysis of *Erteld et al.,* there were only two of nine case studies in which the factor male foetus had a significant increasing effect on the arising of a uterine torsion. When the birth weight is over 45 kilogrammes, the amount of male calves enduring a uterine torsion significantly increases (14).

FETAL FACTORS: FETAL WEIGHT

As already mentioned, fetal weight is a very important factor, as excessive fetal weight increases the risk of a uterine torsion (5). *Frazer et al.* describes excessive weight in 89% of all cases of uterine torsions. The mean fetal weight in the 44 cases of Holstein calves discussed was 49.7 kilogrammes, whereas breed average weight is only 44.5 kilogrammes. Although the mean weight in Brown Swiss calves was 2.3 kilogrammes higher than breed average, it was not significant (7). The explanation for this phenomenon is that a normal sized foetus is capable of rotating and flexing his limbs near the end of gestation. When a calve is too large, its movements are more powerful, possibly leading to rotation of the uterus (12).

Besides the fact that excessive fetal weight increases the risk for uterine torsions, it is also speculated that fetal oversize is a protecting factor for uterine torsions. In the study of *Faria et al.* only 3.5% of all cows presented with a uterine torsion had a feto-pelvic disproportion (2). It is even stated that small dam size is a protective factor, as the foetus will be relatively bigger in these cows. With the increase of cow size over the years, there may be an increased risk for uterine torsions, as feto-pelvic disproportion is less common (11).

FETAL FACTORS: FETAL PRESENTATION

The way a foetus takes in his position inside the uterus is not thought to be an influencing factor, referring to some authors. *Frazer et al., for example,* describes only 6% of the calves enduring a uterine torsion were in a posterior position. This does not differ significantly from the population average of 4% to 5% of foetuses presented in posterior position (7). *Lyons et al.* found that only 4% of the calves during a uterine torsion is in posterior position (19).However, *Aubry et al.* found a higher amount of calves that endured a uterine torsion in posterior position (11).

It is also suggested that the position of the fetus influences in which way the uterus twists. A higher incidence of anti-clockwise torsions is seen in anterior positioned calves, whereas clockwise torsions are seen more often in posterior positioned calves (14). Besides the overall position, the position inside the pelvis also differs of calves enduring a uterine torsion, compared to other control dystocia calves. For example, *Aubry et al.* describes that 17% of the calves is in dorsoileal position and 43% is in dorsopubic position. This differs from the other control dystocia cases, in which 60% of the calves were in dorsosacral position (11).

FETAL FACTORS: SINGLE OR TWIN PREGNANCY

It is suggested that a bicornual disposed twin leads to a stabilisation of the uterus (5). The prevalence of bicornual pregnancies ranges from 50% to 90% (7). It would therefore be expected that a uterine torsion during a twin pregnancy is very rare, however, there are some cases (5). Both *Lyons et al., Aubry et al., Mock et al.* and *Faria et al.* describe about 3% to 4% twin pregnancies out of their cases of uterine torsions (2,10,11,13). On the other hand, *Aubry et al.* describes an incidence of 14% of twins in the control dystocia. This may be contributed to the fact that twinning often leads to dystocia, due to the smaller space in the uterus. So, twinning leads to an increase in dystocia, but is a protective factor for uterine torsions (11).

CONCLUSION: FETAL FACTORS

Study results regarding fetal gender and the incidence of uterine torsions are varying. Some studies found that male calves were more often involved in a uterine torsion (7,14). However, others did not find the same distribution (19). It is more clear that excessive fetal weight increases the risk for a uterine torsion (5,7,12). The higher amount of male calves involved in a uterine torsion could possibly be explained by the higher birth weight of these calves. In all studies regarding intra-uterine position of the calve, it was found that most calves involved in a uterine torsion are in anterior position (7,11,19). It was also found that a bicornual disposed twin is less at risk for a uterine torsion (5,7). However, there are cases of twin pregnancies present which end up with a uterine torsion (2,10,11,13).

INCIDENCE OF UTERINE TORSIONS

Very few articles on the incidence of uterine torsions in dairy cows are available. Most of these articles calculate the number of uterine torsions as part as the total number of dystocia. However, most studies use a very small sample group, which unfortunately leads to less reliable results (2,11,16,19). In some studies, the sample size was not even noted, which makes it hard to interpret the reliability of the results (13,17,18).

As described, the incidence of uterine torsions differs across the world. These dissimilarities come from other housing types, breeds and other management factors (7,11). Moreover, there are differences in incidence of uterine torsion within the same country. This may be contributed to differences in the study designs. Several results of incidence studies are represented in table 3.

Lawrence *et al.* reported an increase of uterine torsions in the period 1997 till 2007. This study was established to see the effects of the foot-and- mouth disease on the incidence of both uterine torsions and left abomasal displacement. The number of left abomasal displacements had increased by 150% and the incidence of uterine torsions with 35% in this period. The number of uterine torsions as part of the total cases of dystocia increased from 11.3% to 15.5% (18). Overall, table 3 shows that there are big differences in the number of uterine torsions found in different countries and periods of time. It also shows that the incidence in the Netherlands has never been measured.

MATERIAL AND METHODS

DATASET 1: INCIDENCE OF UTERINE TORSIONS

To investigate the incidence of uterine torsions and the distribution of dystocia in the Netherlands, several veterinary practices were asked to participate in this study. In total, five veterinary practices in the Netherlands shared data of their practice management systems, with all their cases of dystocia in dairy cattle in the years 2015 and 2016. Cases of dystocia delivered by the practices were: assisted vaginal deliveries, fetal malpresentations, caesarean sections, foetotomy,

Table 3: Representation of the incidence of uterine torsions compared to the total number of dystocia. * = Number of uterine torsions seen as percentage of total number of calvings. N.a. = not available.

Author	Year	Dystocia n	Uterine torsion n (%)	Country
Pearson (16)	1971	918	174 (19.0)	United Kingdom
Laven *et al.* (17)	2005	n.a.	n.a. (7.7)	United Kingdom
Lawrence *et al.* (18)	2012	n.a.	n.a. (15.5)	United Kingdom
Lyons *et al.* (10)	2013	322	73 (22.7)	United Kingdom
Lyons *et al.* (19)	2013	20.281 *	(0.24) *	United Kingdom
Frazer *et al.* (7)	1996	105.425 *	790 (0.75) *	USA
Aubry *et al.* (11)	2008	273	55 (20.1)	USA and Canada
Mock *et al.* (13)	2015	n.a.	n.a. (3.0-3.6)	Switzerland
Faria *et al.* (2)	2015	119	29 (24.1)	Portugal

uterine prolapses and uterine torsions. However, not all veterinary practices differentiated between assisted vaginal deliveries and fetal malpresentations. These practices only noted assisted vaginal deliveries and it was unclear if this included a fetal malpresentation. Due to this, fetal malpresentations are added to the number of assisted vaginal deliveries. Uterine prolapses are excluded from this dataset, as they are a complication after parturition and not a cause for dystocia. In total, 3049 cases of dystocia are included in dataset 1. The seasonal distribution of uterine torsions as part of the total of dystocia will be investigated as well; to see if there is a predisposition for a specific season.

Dataset 1 was combined with data of the number of cows at the veterinary practices, in order to calculate the number of dystocias per cow per year. The total number of cows in 2016 was received from all five veterinary practices. However, the total number of cows at these practices was not recorded in 2015. Therefore, nationwide Central Agency for Statistics (CBS) data was used to estimate the number of cows at these five practices in 2015 (1). The CBS found an increase of 7.5% in the number of dairy cows over the years 2015-2016. This was used to estimate the number of cows at the five veterinary practices in 2015. These data were combined to give an estimation of the risk for a calving cow to endure dystocia or a uterine torsion. It is assumed that every cow above two-year age calves every year. At last, the number of uterine torsions at every farm will be displayed to see if this is in agreement with the expected number of uterine torsions per cow.

DATASET 2: INFLUENCE OF EPIDEMIOLOGIC FACTORS

A second, different database was used to examine the influence of age, parity and season on the incidence of uterine torsions. All available cases of uterine torsions at one specific veterinary practice were used, these cases were also used in dataset 1. To find extra information on the epidemiologic factors named, it was first necessary to find the specific cow and farm identification number. Using the programme pir-dap, it was than possible to find age and parity of the cows that endured a uterine torsion. Age, parity and calving data of all other lactating cows at a farm with a uterine torsion were also recorded. This group of cows was then used as a control group to compare with the cows that endured a uterine torsion. In total, dataset 2 consists of 5478 different cows, with in total 92 cases of uterine torsions.

STATISTICS: DATASET 1

Dataset 1 was sorted in groups defined by the cause of dystocia; i.e. assisted vaginal deliveries, caesarean sections, foetotomy and uterine torsions. This data was analysed in excel to find out the distribution of the causes of dystocia. The distribution of uterine torsions and dystocia over the different months and years was also examined. To see if there is an increase or decrease in the incidence of uterine torsions, the total number of cases will be correlated to the total number of dairy cows in the five practices. The number of dystocias will be correlated to the number of dairy cows as well. Also, the number of uterine torsions as part of the total number of dystocia will be calculated. A p-value of <0.05 was used to see if results were significant.

A logistic regression model in the statistical programme RStudio was used to see if the differences in the number of uterine torsions between the two years were significant. Also, a logistic regression model was used to see if there was a significant influence of season on the incidence of uterine torsions. Season was used as a grouped variable to see if there is a significant difference in the incidence of uterine torsions as part of the total number of dystocia. Season was grouped according to the Northern meteorological seasons. For example, the season winter was composed of the months December, January and February. All possible combinations of different seasons will be investigated and, therefore, a Bonferoni correction of 6 was used. A p-value of <0.05 was used to see if results were significant.

STATISTICS: DATASET 2

The statistical programme RStudio was used to investigate if there is a significant influence of age and parity on the incidence of uterine torsions. Firstly, age and parity were analysed by a logistic regression model with age as a continue variable and parity as a grouped variable. Parity was assembled in groups ranging from 1, 2 to 4, 5 to 7 and 8 to 12 parities. First parity animals, so primiparous animals, were separated into one group, as this group is less at risk for a uterine torsion as became clear from literature (11). A likelihood ratio test (LRT) was used to test the relation between the independent and the other variables. Low LRT's mean that a result is less likely to occur under the null-hypothesis, when compared to the alternative-hypothesis.

Secondly, seasonal peaks in the incidence of uterine torsions were examined. All cases of uterine torsions, were compared to the calving moment of the control population of dataset 2.

Calving dates were grouped into seasons, to investigate the seasonal effects on uterine torsions. Season was grouped according to the Northern meteorological seasons. Using a logistic regression model within the programme RStudio, the effect of season was analysed. All possible combinations of seasons were investigated and, therefore, a Bonferoni correction of 6 was needed. A p-value of <0.05 was used to see if results were significant.

RESULTS

DISTRIBUTION OF DYSTOCIA

In total, 3049 cases of dystocia over the years 2015 and 2016 were included in this research. The distribution of the causes of dystocia can be seen in table 4. Results show that of all cases of dystocia, in which a veterinarian is present, 24.0% is a uterine torsion. Also, it can be seen that a veterinarian is most needed for an assisted vaginal delivery (49.4%).

Table 4: Distribution of dystocia over the years 2015 and 2016 together.

Cause of dystocia	Number (n)	Percentage (%)
Assisted vaginal delivery	1507	49.4
Caesarean section	742	24.3
Foetotomy	69	2.4
Uterine torsion	731	24.0
Total	3049	100

Figure 2 shows that the number of dystocia differs over the months. Especially in the month December there are few cases (205/3049), when compared to other months. The most cases of dystocia are seen in the months May (288/3049), June (279/3049) and September (283/3049). In April, the lowest percentage of uterine torsions as part of the total number of dystocia is seen (15.9%); in September the highest (29.0%).

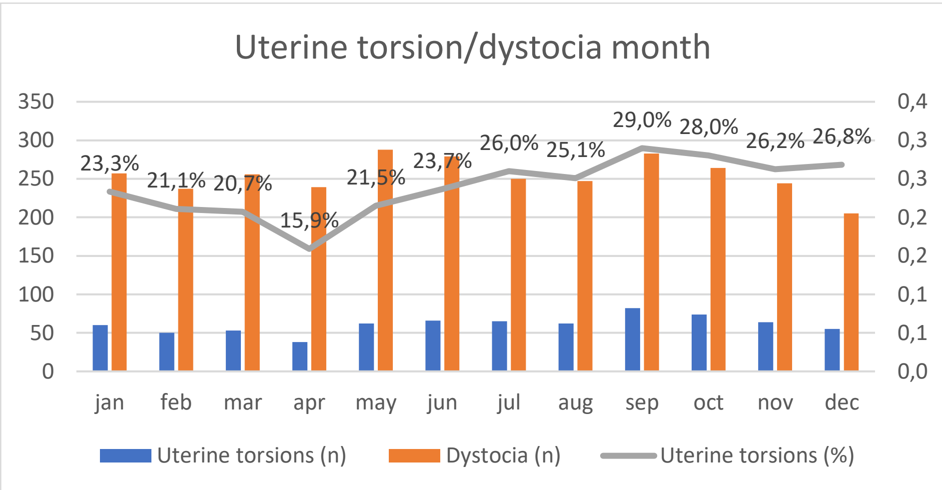

Figure 2: Distribution of uterine torsions as part as the total number of dystocia in 2015 and 2016. Percentage of uterine torsions as part of total number of dystocia is represented by the linear grey line.

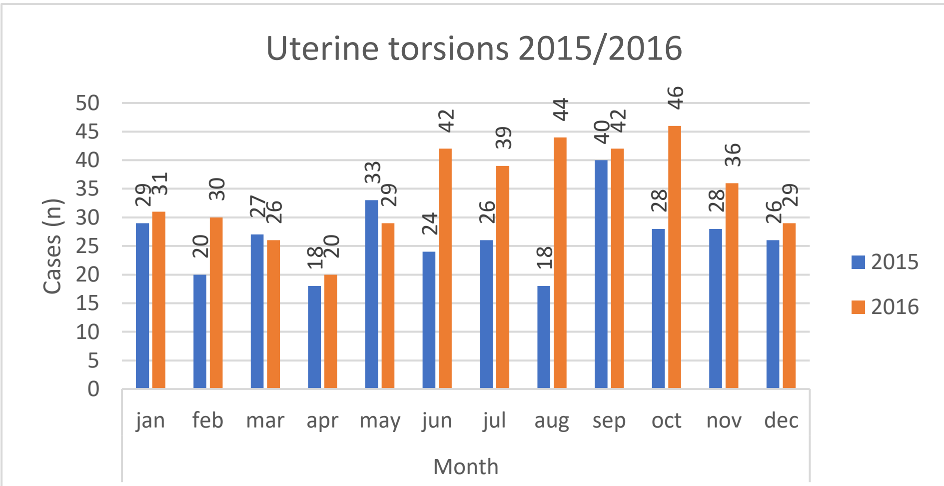

Figure 3: Distribution of uterine torsions over the different months, 2015 and 2016 separated.

DISTRIBUTION OF UTERINE TORSIONS PER MONTH

Figure 3 shows the amount of uterine torsions in the years 2015 and 2016 apart. Looking at figure 3, big differences in the incidences between the years 2015 and 2016 can be seen. Especially in the month August, there is a high increase of uterine torsions in the year 2016.

Looking at the years 2015 and 2016 together, the number of uterine torsions is highest in the month September (82/731) and lowest in the month April (38/731).

DISTRIBUTION OF UTERINE TORSIONS PER SEASON

As can be seen in table 5, the number of uterine torsions (cases) as part of the total number of dystocias, differ over the seasons. Most cases of uterine torsions as part of the total cases of dystocia are seen in autumn (38.7%); which are months September, October and November. Of all possible combinations of seasons, it became clear that there is a significant difference in incidence between the seasons spring and autumn. As visualised in table 5, there are significantly less uterine torsions in spring, when compared to autumn (P-value = 0.00073).

INCREASE IN INCIDENCE OF UTERINE TORSIONS

As can be seen with the linear tangent in figure 4, the incidence of uterine torsions increases in the period 2015-2016. Especially during the end of the spring and the summer in the year 2016, the number of uterine torsions is extremely high. However, it is necessary to correlate the total number of uterine torsions to the total number of cows, as it can be an effect of the increasing number of cows.

Data representing the number of cows and the risk for a uterine torsion per cow is represented in table 6. The total number of cows at the five practices increased with 6.563 cows (7.5%) over the period 2015-2016. Also, the number of uterine torsions grew from 317 to 414 in one year time. This numerical increase in the incidence of uterine torsions is significant with an P-value of 0.00076. Also, the chances of a cow enduring a uterine torsion, increases in the period 2015-2016.
Whereas a cow in 2015 had a chance of 0.360% to endure a uterine torsion, the chance increased to 0.438% in 2016. Moreover, the amount of uterine torsions as part of the total number of dystocia has increased from 21.3% in 2015 to 26.6% in 2016. If we compare this to the number of dystocia, it can

Table 5: Distribution of uterine torsions per season. Cases of uterine torsions of all veterinary practices. As a control, all other cases of dystocia are used.

Season	Cases (n)	Controls (n)	Cases/controls (%)	P-value	Odds ratio	95% CI
Winter (DJF)	165	534	30.9	0.064	0.80	0.63-1.01
Spring (MAM)	153	630	24.3	<u>0.00073</u>	<u>0.63</u>	<u>0.50-0.80</u>
Summer (JJA)	193	583	33.1	0.19	0.86	0.69-1.08
Autumn (SON)	221	571	38.7	Reference	Reference	Reference

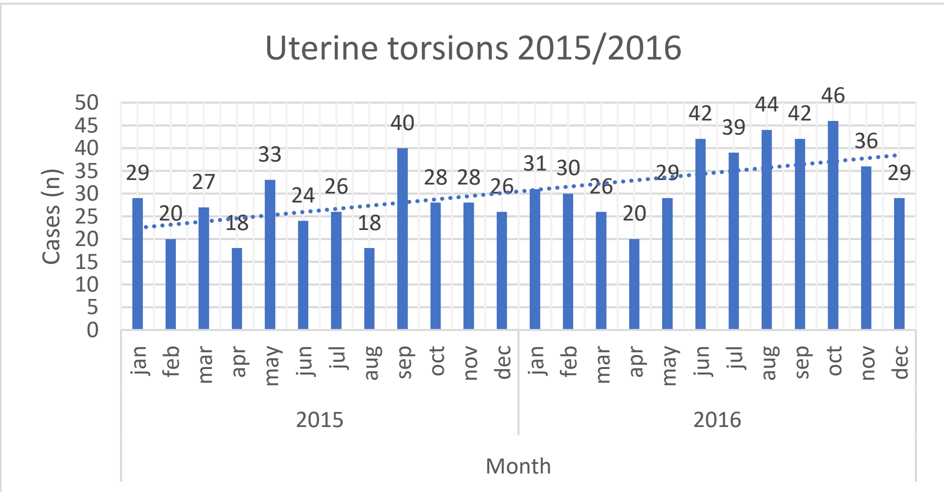

Figure 4: Distribution of uterine torsions per month, 2015 and 2016 separated. The tangent shows an increase of The tangent shows an increase of uterine torsions over this period.

Table 6: Representation of the amount of dystocia and uterine torsions per cow over the year 2015 and 2016. Also, the number of uterine torsions as part of the total number of dystocia is represented.

Veterinary practice	A	B	C	D	E	Total
Cows in 2015 (n)	24905	17807	16061	18143	11066	87982
Torsions in 2015 (n)	74	97	58	41	47	317
Dystocia in 2015 (n)	558	293	186	245	208	1490
Torsion/dystocia 2015 (%)	13.3	33.1	31.2	16.7	22.6	21.3 ± 7.0
Torsion/cow 2015 (%)	0.30	0.54	0.36	0.23	0.42	0.36 ± 0.1
Dystocia/cow 2015 (%)	2.24	1.65	1.16	1.35	1.88	1.69 ± 0.3
Cows in 2016 (n)	26763	19135	17259	19496	11892	94545
Torsions in 2016 (n)	96	112	65	77	64	414
Dystocia in 2016 (n)	518	326	191	286	238	1559
Torsion/dystocia 2016 (%)	18.5	34.4	34.0	26.9	26.9	26.6 ± 4.8
Torsion/cow 2016 (%)	0.36	0.59	0.38	0.39	0.54	0.44 ± 0.1
Dystocia/cow 2016 (%)	1.94	1.70	1.11	1.47	2.00	1.65 ± 0.3

Table 7: Number of uterine torsions at a farm in 2015 and 2016

Uterine torsions in 2015 and 2016 (n)	Farms (n)
1-2	321
3-4	74
>4	12

Table 8: Distribution of cases of uterine torsions per season of one specific veterinary practice and as control all lactating cows at farms with a case of a uterine torsion.

Season	Cases (n)	Controls (n)	Cases/controls (%)	P-value	Odds ratio	95% CI
Winter (DJF)	12	1272	0.94	<u>0.015</u>	<u>0.40</u>	<u>0.22-0.71</u>
Spring (MAM)	16	1166	0.01	0.060	0.47	0.26-0.82
Summer (JJA)	19	1410	1.35	<u>0.0075</u>	<u>0.39</u>	<u>0.21-0.67</u>
Autumn (SON)	45	1538	2.92	Reference	Reference	Reference

be see that the chances of a cow enduring any form of dystocia has not changed dramatically. The chances of a cow having dystocia was 1.69% in 2015 and this decreased to 1.65% in 2016.

DISTRIBUTION OF UTERINE TORSIONS PER FARM

The risk of a cow enduring a uterine torsion ranges from 0.360% in 2015 to 0.438% in 2016 as is represented in table 7. For example, this means that a farm with 130 cows has a change to have one cow that is diagnosed with a uterine torsion in two years. Results show that there are farms which have cows diagnosed with a uterine torsion more often. For example, there are 74 farms in this dataset with three or four uterine torsions and 12 farms with even more than four uterine torsions in two year.

INFLUENCE OF SEASON

To see if season is a risk factor for uterine torsions, all cases of uterine torsions of one practice (92/731) were compared to a control group. This control group consisted of all lactating dairy cows from each farm with a uterine torsion. The control group consisted of 5386 cows in total. The distribution over the different seasons of cases and controls can be seen in table 8. Reference month autumn is represented in table 8. Eventually, a significant influence of season on the incidence of uterine torsions was found. According to these results the risk for a uterine torsion is significantly higher in autumn, when compared to winter and summer. Winter had a significant lower incidence with a P-value of 0.015 and summer had a significant lower incidence with a P-value of 0.0075 when compared to autumn.

INFLUENCE OF AGE

In this study, most cows enduring a uterine torsion were found in the groups 2 to <4 years (37/92) and 4 to <6 years (36/92), but this difference was not significant. A P-value of 0.37 and a LRT of 0.81 were found. See table 9 for age distribution in this study.

Table 9: Age distribution of cows with a uterine torsion. Cases of uterine torsions of one specific veterinary practice and as control all lactating cows at farms with a case of a uterine torsion.

Age (years)	Cases (n)	Controls (n)	Cases/controls (%)	Total (n)
0 to <2	2	88	2.27	90
2 to <4	37	2736	1.35	2773
4 to <6	36	1485	2.42	1521
6 to <8	11	730	1.51	741
8 to <10	5	261	1.92	266
10 to <12	1	60	1.67	61
12 to <14	0	18	0	18
14 to <16	0	8	0	8

Table 10: Parity distribution of cows with a uterine torsion. Cases of uterine torsions of one specific veterinary practice and as control all lactating cows at farms with a case of a uterine torsion.

Parity	Cases (n)	Controls (n)	Cases/controls (%)	Total (n)	P-value
1	18	1546	1.16	1564	Reference
2-4	59	2910	2.03	2969	0.34
5-7	14	813	1.72	827	0.83
8-12	1	117	0.85	118	0.40

INFLUENCE OF PARITY

Age and parity are strongly correlated to each other, because the time between two calvings is preferably about one year. Also, most cows are around two-year-old, at their first calving. However, to prevent bias, individual parities have been recorded. Parity was not found a significant factor in this study when grouped as in table 10, with a P-value of 0.16 and a LRT of 5.18.

DISCUSSION

In total, five veterinary practices participating in this study reported 3049 cases of dystocia over the years 2015 and 2016. In this study, an incidence of 24.0% for uterine torsions as part of the total number of dystocia over the years 2015 and 2016 was found. The amount of uterine torsions as part of the total cases of dystocia increased from 21.3% in 2015 to 26.6% in 2016. Moreover, the risk for a uterine torsion per cow has increased. Whereas a cow had a chance of 0.360% to endure a uterine torsion in 2015, this increased to 0.438% in 2016. It was found that 407 farms had at least one uterine torsion in two years. In 12 farms, there were over four cases of uterine torsions in two years. This study found a significant influence of season on the incidence of uterine torsions, when compared to the seasonality of other cases of dystocia. In autumn, there was a significant higher incidence of uterine torsions, when compared to spring. Also, when the cases of uterine torsions of one specific veterinary practice were compared to the calving pattern in the control population, a significant influence of season was found. In this case, cows calving in autumn were found to have a higher risk of getting uterine torsions, when compared to cows calving in winter and summer. Age and parity seem to not have a significant influence on the appearance of uterine torsions.

The incidence of uterine torsions in dairy cows in the Netherlands has not been reported yet. The incidence of 24.0% for uterine torsions as part of the total number of dystocia found in this study is comparable with several other studies. For example, it is relatively similar to the results of *Faria et al.,* with an incidence of 24.1%; *Lyons et al.,* with an incidence of 22.7%; and *Aubry et al.,* with an incidence of 20.1% (2,10,11). However, other studies mentioned lower incidences like 19.0%, 7.7%, 15.5% and even 3.0% to 3.6% (13,16–18). It is unclear why there are such big differences in incidence; it could possibly be an effect of different study designs. Another explanation are the regional differences in bovine breeds. As mentioned, some breeds are at higher risks for uterine torsions (7,12–15). However, due to the small sample groups in other studies, the results of this study may be more reliable. It is questionable if the number of uterine torsions is accurate or an underestimation. Some farmers are able to correct a uterine torsion by themselves, because of their experience with uterine torsion, as mentioned by *frazer et al* (7). In addition, there are some obstetricians that are not appertained to a veterinary practice, but do help in case of a difficult parturition. This leads to an underestimation of the total number of uterine torsions and in the last case also an underestimation of the total number of dystocia. Also, the true definition of a uterine torsion may differ between the practices; and even between veterinarians. *Frazer et al.* speaks of a uterine torsion when the uterus is rotated for only 45˚. But, he also reports that there is a chance that the uterus corrects itself spontaneously (7). At the University of Utrecht, only torsions of over 180˚ are defined as a uterine torsion (24). It remains unclear what the different veterinarians in the practices involved in this research study used as definition for a uterine torsion.

This study showed an increase in the incidence of uterine torsions as part of the total number of dystocia over the period 2015-2016. The risk for each cow to have a uterine torsion increased significantly from 0.360% in 2015 to 0.438% in 2016. It is unclear why there is such an increase in incidence over this period. This could be coincidence, but there are other possible theories. For example, the increase in incidence could be caused by the expansion of the farms, which led to more cows in the same amount of space. Therefore, it is easier to be bumped in the side by another cow, which is a risk factor as mentioned by *Ghuman* (12). However, it could also be an genetic effect, as taller cows and cows with a deeper abdomen are more at risk for uterine torsions (15,26).

It is hard to admit to an increase of uterine torsions over a longer period, as this study only incorporated data of the years 2015 and 2016. It would be more specific if data of more years was included in this research. Also, the number of cows at the five practices was not fully documented. The practices included in this research, started recording the number of cows in their practice in the year 2016. The estimation of the number of cows in 2015 was based on nationwide Central Agency for Statistics (CBS) data, which makes the data for individual practices less reliable. Therefore, the incidence in uterine torsions between 2015 and 2016 remains difficult to compare.

As mentioned, there were 407 farms that endured a uterine torsion in two years. It is, however, remarkable that there are 12 farms that had more than four uterine torsions in the same period. It can be speculated that this is due to the number of cows at a specific farm. This information was, unfortunately, not available for this study. It is also possible that the high incidence of uterine torsions at these farms is an effect of the cow management, cow genetics or animal housing.

Whereas *Frazer et al.* did found significant influence of age on the incidence of uterine torsions, this was not found in our study (7). No significant influence of parity was seen as well. On the other hand, season was found to be a significant factor when cases of uterine torsions were compared to the other cases of dystocia. There was a higher incidence of uterine torsions in autumn, when compared to spring (P-value = 0.00073). However, when the cases of uterine torsions of one practice were compared to calving pattern in the control population, autumn had a significant higher incidence compared to summer (P-value = 0.0075) and winter (P-value = 0.015). *Lawrence et al.* described the incidence of uterine torsions as moderately to strongly seasonal (18). The same seasonal effect was not found in other studies. *Frazer et al.* and *Mock et al.* did not even notice a seasonal effect (7,13). *Aubry et al.* does describe a seasonal influence, however, this study found the highest amount of uterine torsions in the summer and the winter (11). It is strange that the different datasets differ in their results. This could be an effect of the different control groups and the lower amount of cases in dataset 2. Overall, the results show a higher incidence in autumn. This could be an effect of the end of the period in which the cows are pastured. Most cows are stalled in the period of autumn and winter.

In this study, it was difficult to investigate if there is a relationship between the appearance of uterine torsions and the factors season, age and parity. To have a reliable result, more specific information would be necessary. In only one of the five veterinary practices, it was possible to search retrospectively for the specific identification number of the cow and farm (UBN); which was needed to find the age and parity of each cow which had endured a uterine torsion. With the programme pir-dap it then became possible to sort out every case by the UBN of the farmer and then to find each cow by their specific cow identification number. However, of all 170 cases of uterine torsions, not all cow identification numbers were found. Also, not all UBNs were listed in pir-dap and not every cow was retrieved by their identification number in the list of cows. Of the 170 cases of uterine torsions, only 92 cases had complete information. Due to the smaller group with cases, it was harder to interpret the results of the statistics regarding influence of season, age and parity on the incidence of uterine torsions. As a control group for these statistics, all other lactating cows at the farm at time of a uterine torsion were used. But only when the complete information of the cow that endured a uterine torsion was available. Age, parity and calving date were notated of this control group. The list in pir-dap only represented the lactating cows at that moment, possibly leading to a misinterpretation of especially the calving date of all cows. Overall, this makes the results of the statistics for especially season less reliable. In future studies, it is, therefore, needed to look at all lactating cows in a year and not at a specific moment.

In general, in our study it was hard to investigate risk factors for uterine torsions, because this retrospective study had limited information. Data was not fully documented or registered in different ways, which made it hard to compare data. It would be interesting to do another prospective study, in which other factors could be analysed. Also, it would be interesting to investigate the influence of season, age and parity again on a larger scale. Ultimately, It would be interesting to look at the incidence of uterine torsions as a whole over a longer period as well.

CONCLUSION

The incidence of uterine torsions in dairy cows, as seen as part of the total of dystocia in five veterinary practices in the Netherlands, was 24.0%. The number of uterine torsions as part of all cases of dystocia increased from 21.3% to 26.6% in the period 2015 to 2016, respectively. The incidence of uterine torsions per cow increased from 0.360% in 2015 to 0.438% in 2016. In this study, a significant influence of season on the incidence of uterine torsions was found with significantly more uterine torsions in autumn. This compared to spring, with the other cases of dystocia as a control. However, when all the other lactating cows at a farm with a uterine torsion were used as a control, there was a significant higher incidence in autumn when compared to winter and summer. Age and parity seem to not have a significant influence on the incidence of uterine torsions. For future studies, it is also interesting to look at factors as type of housing, breed, stage of gestation, gender of the foetus, fetal weight, presentation of the foetus and single or twin pregnancies. It also would be interesting to document the incidence of uterine torsions over a longer period, to see if there is a true increase of uterine torsions.

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