



## The Caesarean Operation in Cattle: a Review

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### Introduction

Dystocia in cattle can be relieved by different obstetric methods, including the caesarean operation and fetotomy. Nowadays, the caesarean operation is one of the most common surgical procedures performed by veterinarians in cattle practice, and is considered as a routine obstetric technique. It has high maternal and fetal survival rates, and often is less exhausting, speedier and safer than fetotomy. There are three main goals: (1) survival of the cow; (2) survival of the calf; and (3) maintenance of fertility. A prompt decision to perform a caesarean operation is important for optimum success. Ideally, it is carried out when a live calf cannot be delivered after 15-20 minutes of manipulation. The cow is a good surgical risk, provided that the environment is suitable for aseptic abdominal surgery. The need for urgent intervention is indicated if there is evidence of fetal hypoxia, as shown by hyperactive movements of the fetus and expulsion of the meconium, identifiable in the amniotic fluid. A successful prognosis depends on several factors, such as the skill and speed of the surgeon, duration of dystocia, physical condition of the dam, surgical environment, concurrent disease, and presence of a live calf.

### Indications

The indications for a caesarean operation and the reasoning behind an appropriate decision have been extensively reviewed. Analysis of published cases shows that the following six major indications account cumulatively for 90% of all caesarean operations:

1. Fetomaternal or fetopelvic disproportion (either relative or absolute fetal oversize)
2. Incomplete dilatation or induration of the cervix
3. Uterine torsion that cannot be corrected otherwise
4. Fetal monsters

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5. Faulty fetal disposition (presentation, position or posture)
6. Fetal emphysema.

In some cases, caesarean operation is scheduled a few days before term to deliver valuable calves without the risk of vaginal delivery (so-called 'elective surgery').

If the birth canal is fully dilated, fetal causes of dystocia may be amenable to relief by fetotomy, but failure of cervical dilatation and irreducible uterine torsion are absolute indications for surgery. Non-surgical delivery may seem advisable if the fetus is grossly infected, but laparohysterotomy is often obligatory in such cases because of premature uterine involution, emphysema of the fetus or constriction of the birth canal. In many cases of dystocia, fetotomy may be the preferred option. However, the choice between caesarean operation and fetotomy will, to a certain extent, depend on the veterinarian's preference and relative experience with either technique.

### **Surgical Approaches**

Different surgical approaches have been developed for the caesarean operation in cattle, with each having its advantages in specific situations. Considerations crucial to the choice of approach include: (i) the veterinarian's experience and confidence; (ii) the nature of the environment (e.g. whether or not there is a crush or head bail for standing restraint); (iii) the kind of assistance that is available; and (iv) the physical condition of the animal (e.g. whether it can stand for the entire procedure, whether the rumen is distended or whether there is evidence of calving paralysis due to prolonged dystocia).

The options of patient positioning for caesarean operation are:

1. Standing (suitable for left or right paralumbar fossa and lateral oblique approach)
2. Dorsal recumbency (suitable for ventral midline and paramedian approach)
3. Sternal recumbency (suitable for left or right paralumbar fossa)
4. Lateral recumbency (suitable for ventrolateral and low-flank approach).

The choice depends on the surgeon's preference, demeanour of the animal, as well as available facilities. In a cow capable of tolerating surgery while standing, the left paralumbar fossa or flank approach is the standard technique for a viable or recently dead, uncontaminated fetus. Other indications for this approach include cows with a large udder, extensive oedema of the udder and ventral abdomen, or prolific ventral abdominal vascularity close to the milk vein, such as occurs in mature dairy cattle. One advantage of the left flank incision is that the rumen can be used to prevent exposure of the intestines. However, in individual cases, a large rumen, particularly if the animal is straining, can interfere with surgical access to the abdomen. Another advantage of the flank approach in the standing animal is easier correction of uterine torsion. Finally, wound dehiscence is more manageable in the flank, compared with lower abdominal incisions. The standing left paralumbar fossa approach is favoured by most veterinarians and is described in detail below. The other approaches are briefly discussed for completeness.

### **Restraint and Preparation for Surgery**

The surgeon usually has little choice when selecting the operating environment for a caesarean operation. Many successful operations have been performed under less than ideal circumstances in pastures, barns, sheds, and milking parlours. If a hospital facility is not available, attention must be given to choosing the cleanest possible surroundings, as the operating environment has been shown to be a significant source of organisms that contaminate the wound. Also the location for surgery should be selected carefully with the objectives of ensuring good lighting, facilities for restraint and a suitable floor surface. Avoid performing surgery in buildings occupied by large numbers of other cattle. Ideally, use a clean calving pen or other unoccupied building. Clean bedding should be provided, although vigorous shaking of straw will cause unwanted clouds of dust. Lighting should be provided that illuminates the desired surgical site. The surgeon should ensure that the light is not placed such that the surgical site is in the shadow cast by the surgeon; equally, the light must not shine in the eyes and distract the surgeon. Many veterinarians carry a portable halogen lamp and stand, for use on the farm; alternatively, one solution is for the surgeon to wear a head-torch.

For standing surgery, a tractable animal can be restrained using a halter, preferably in a calving pen, tied such that the animal's right flank is against a wall and the head is in the corner, in order to limit movement during surgery. The halter should be tied with a quick-release knot in case the cow suddenly becomes recumbent. If needed, the animal can also be positioned against the exit gate of the left bail area in the milking parlour. A strategically fastened side rope should prevent the animal from turning around. More fractious animals are best restrained in a crush or head bail, which must provide good access to the incision site, i.e. the left side of the animal in most cases. Nose grips are often required for additional restraint.

Facilities for restraint should be appropriate for the size of animal and designed to avoid injury to animals or humans. A ring fixed in the wall of a calving box and offset 50 cm from the corner is ideal; if the animal goes down the offset ring encourages the animal to lie on her right side. The floor surface should provide adequate friction for animal and surgeon. Slippery concrete floors can lead to accidental falls during surgery. A 20–30 cm-thick base of sand, with clean straw on top, provides an ideal surface. Facilities for the calf should also be prepared at this stage; a warm, straw pen complete with resuscitation equipment would be ideal.

Sedation should be avoided, if possible, because it can cause recumbency during surgery and may be detrimental to fetal survival. If sedation is necessary, xylazine is commonly used (0.05-0.1 mg/kg intramuscular or a reduced dose intravenously; however, the latter is not a licensed route of administration in some countries). Unfortunately, xylazine has an ebolic effect (i.e. it stimulates contraction in the uterus at term), making surgery more difficult, and can cause rumen tympany, which can obstruct the surgical wound. A rope can be attached to the right hind leg above the fetlock and laid underneath the animal's body so that if the cow becomes recumbent during surgery, the rope can be pulled to enable the animal to lie in right lateral recumbency. The tail is tied out of reach of the operative site, usually to the halter along the right side of the animal or to the right hock. Acetylpromazine maleate (0.05-0.1 mg/kg IM or IV) can also be used as a sedative for the caesarean operation, as it does not induce uterine contractions.

Alternatively, surgery may be performed on the recumbent animal; this is particularly indicated for fractious animals. If the cow is not already recumbent, a sedative can be

administered (e.g. xylazine 0.2 mg/kg intramuscular) or the animal cast, using a rope. The animal should be placed in right lateral or semi-sternal recumbency with the body slightly tilted to the right. Bales of straw may be used to prop the cow in a stable position for surgery. In addition, the legs may be hobbled, while some surgeons prefer the left hind leg to be extended caudally and fixed by a rope.

Two or more assistants are usually required for successful surgery: as a minimum, one to restrain the cow and one to deliver the calf. Communication with the assistants by the surgeon is important. Briefly describe how the surgery will be performed, and outline the role of each assistant and how to proceed in the case of a crisis such as recumbency of the cow during surgery.

### **Anaesthesia**

The choice of anaesthetic method varies between surgeons and the selected surgical site. For flank incisions, paravertebral anaesthesia of the nerves associated with the transverse processes of T13, L1, L2 and L3 is commonly recommended. Each site is infused using 20ml of a 2-3% lignocaine solution; around 10-15 ml to block the ventral nerve branches, 5-10 ml for the dorsal branches. Signs of successful anaesthesia are a warm, hyperaemic and flaccid flank with no response to pain when tested with a hypodermic needle. The advantage of paravertebral anaesthesia is that the entire flank, including the peritoneum, is desensitised and flaccid, which facilitates exploration of the abdomen during surgery and closure of the wound. Also the flank incision can be extended readily if necessary during surgery. One disadvantage is that the technique is more difficult to perform than other methods; it requires some experience and practice for reliable results. In addition, the cow may be unsteady after surgery due to loss of lumbar muscle tone and paresis of the ipsilateral hindlimb; the latter may complicate this method of anaesthesia, especially if footing for the animal is uncertain. Therefore, care must be taken not to inject an excessive dose of anaesthetic around the third lumbar nerve, since it contributes branches to the femoral and obturator nerves. Finally, the vasodilatation in the muscle layers causes a greater degree of haemorrhage that may require haemostasis.

A local anaesthetic line block or inverted-L block of the flank is an excellent alternative to paravertebral anaesthesia. An 18-gauge  $\times$  1.5-inch needle is used to administer 2% lignocaine hydrochloride at several sites; the number of sites is dependent on the length of the proposed incision. At each point, 5 ml of local anaesthetic is injected subcutaneously in each direction of the incision line, and a further 10 ml into the musculature. Normally, only a total of 80-100 ml of lignocaine is required; larger volumes of local anaesthetic solution infiltrated into the incision area may have an adverse effect on wound healing. The technique is quick and reliable, and requires minimal training. However, the parietal peritoneum may not be effectively anaesthetised, causing reaction by the patient when it is incised. Particular problems of inadequate analgesia with an inverted-L block can occur in fat animals. A similar reaction will occur if the incision has to be extended during surgery to extract the calf. Furthermore, because the flank is not flaccid, apposition and suturing of the muscle layers can be difficult.

High epidural anaesthesia, using 2% lignocaine, can provide adequate anaesthesia of the flank, although such anaesthesia also tends to cause recumbency, which may be prolonged in cattle. It has been reported that epidural anaesthesia, using 0.07 mg/kg

xylazine, produces good analgesia for caesarean in about 50% of cases without severe ataxia. However, there is a prolonged time to onset of anaesthesia, and it was not effective in 17% of cases.

### **Pre-Operative Preparation**

Pre-operative antibiotics is strongly recommended. Commonly, 10 mg/kg each of an antibiotic mixture of procaine penicillin and dihydrostreptomycin, or an alternative effective antibiotic, is administered intramuscularly. Tocolytic agents, such as isoxsuprine lactate (220-250 mg; when xylazine sedation is used, it is recommended to increase the dose by 100%) and the  $\beta$ 2-adrenoceptor stimulant clenbuterol hydrochloride (0.3 mg) administered by intramuscular or slow intravenous injection, are widely used and can facilitate the manipulation and exteriorisation of the uterus during surgery; furthermore, they counter the rebolic effect of xylazine on the uterus. A low epidural injection (posterior block) with 4-5 ml of 2% lignocaine is essential to alleviate abdominal straining. It also results in the animal standing more quietly, although an excessive dose may diminish control of the hindlimbs and the animal may become unexpectedly recumbent. Unfortunately, severe tenesmus occasionally fails to be prevented by epidural anaesthesia. In case of an anterior presentation (with the head of the fetus entered into the pelvis), it is important to repel the calf back into the relaxed uterus after the epidural and tocolytic drugs have taken their effect. This will reduce the chances of continuous straining and the cow becoming recumbent during surgery. (Note: tocolytic drugs may have a milk and/or meat withholding time, which then also applies to the fetus).

A wide surgical field should be prepared. Initially, dirt and dust should be brushed from the flank and back of the animal before the operative field is clipped or shaved. In the case of a flank incision, the entire flank should be clipped from below the transverse processes dorsally, to just above the milk vein ventrally, and from the last rib to the hind leg, level with the tuber coxae. The skin should be prepared using a surgical scrub (7.5% povidone-iodine or 4% chlorhexidene gluconate solution) followed by surgical spirit. Sterile drapes should be applied; in the standing animal a large single drape with a suitable window can be placed over the back of the cow and down the flank. A useful alternative in the field is to use a wide roll of plastic film wrapped around the cow's body leaving only the surgical site exposed.

Ideally, surgeons and assistants should wear protective surgical scrub suits, even in the field situation. Alternative, a clean and disinfected apron can be used. Many practicing veterinarians prefer not to wear gowns and gloves, in which case the surgeon's arms (all the way up including the armpit and shoulder) should be bare, washed and scrubbed thoroughly. However, due consideration should be given to wearing long-sleeved plastic gloves (rectal examination sleeves, with the finger tips cut off, and the gloves held in place with elastic bands) and surgical gloves, particularly by those veterinarians who do not wear protective gloves for claw trimming and other work in cattle practice that causes gross contamination of the hands.

### **Operative Technique (Described for a Right-Handed Person)**

The adequacy of anaesthesia should be carefully tested before surgery is started, because the muscle and peritoneum may remain sensitive despite skin desensitisation.

### ***I: Left paralumbar fossa approach***

The left flank incision is the most common technique and is most appropriate for the standing animal. The surgeon has to judge whether the animal will remain standing during the procedure; if not, recumbency prior to surgery should be induced.

A vertical skin incision is made in the middle of the left flank starting 10-15 cm ventral to the transverse processes of the lumbar vertebrae, midway between the last rib and the tuber coxae, and extending approximately 30-40 cm long. If the breed of dam or other indication for surgery suggests that future elective caesarean operations may be necessary, the first incision should be made at the cranial border of the flank, just behind the last rib, thus allowing for subsequent incisions to be made more caudally.

With the left flank approach the following muscle layers are incised: cutaneous, external abdominal oblique, internal abdominal oblique and the transverse abdominal muscle. The external and internal abdominal oblique muscles are sharply incised in the same direction, using a scalpel. Haemorrhage from these muscle layers is usually minimal; however, when large vessels are involved, haemostats should be applied and the vessel ligatured if necessary. The aponeurotic transverse abdominal muscle is split vertically by blunt dissection. The peritoneum is tented and cut at the dorsal aspect of the incision, using scissors, taking care not to cut the rumen which lies immediately beneath the peritoneum. At this stage, entry into the abdominal cavity is obtained, which is usually signaled by the sound of air entering the potential space. The incision is then extended vertically with blunt-tipped scissors, rather than a scalpel, to reduce the risk of cutting abdominal organs. Often, a variable amount of peritoneal fluid, sometimes blood-tinged, is immediately apparent in the abdominal cavity. Greater volumes are present in cases of prolonged dystocia, uterine infection, torsion or rupture. Additionally, in the case of uterine torsion or uterine infection, there may be large fibrin clots present in the abdomen. In cases of uterine torsion, the small intestines may also be displaced to a position immediately caudal to the rumen to such an extent that loops may spill through the abdominal incision. The surgeon should now explore the abdomen to identify the uterus, and the uterine tone and the disposition of the calf should be noted. Usually, the tip of the pregnant horn is located in the left lower quadrant of the abdomen, close to the flank incision.

### ***Calf in anterior presentation***

With this presentation, the hind limbs of the calf are situated in the tip of the pregnant uterine horn. Ideally, one or both hind limbs should be anchored in the incision, thereby holding the uterine horn outside the abdomen. One of the fetal limbs is used as a handle to bring the uterine horn near the abdominal incision. To aid exteriorisation of the uterus, the left hand should first locate the calf's digits, then follow the metatarsus down, and finally hold one or both hocks. Now the right hand grasps the digits in the tip of the horn from the medial side, and then pulls the tip of the horn into the incision. The hock is now lifted, so levering the lower limb up through the incision. Often, it is then possible to lock the hock into the ventral commissure of the incision, whilst the digits are retained by the flank above the dorsal aspect of the incision, thereby relieving the tension on the

surgeon's arms. **Note.** The tip of the uterine horn should not be grasped without including one of the calf's limbs, as this may tear the uterus.

Exteriorisation of the uterus before incising the uterine wall is a critical step in the subsequent success of the surgery, as severe wound complications following caesarean operation are associated with incomplete exposure of the uterus. However, traction on the uterus may require considerable strength and tenacity on the part of the surgeon, especially in cases of large fetuses. Manipulation of the uterus also causes stretching of the mesometrium and can cause pain manifested by grunting and the cow displaying other signs of discomfort. Furthermore, once the uterus has been handled the myometrium often contracts, making exteriorisation more difficult, unless a tocolytic agent has been administered prior to surgery.

The uterine wall is incised over the calf's leg using a scalpel or scissors, and the incision needs to be made large enough to allow removal of the calf, without further tearing of the uterus or the need to extend the uterine incision. Therefore, the incision should be made from just below the digits right down to hock, along the greater curvature of the uterine horn, and parallel to the longitudinal muscle layers of the myometrium. If the incision in the uterus is too short, the uterus may tear uncontrollably during extraction of the calf. If the incision extends too close to the cervix, suture repair may be difficult. Care should be taken to avoid incising the calf, particularly if fetal fluids are sparse. In addition, the surgeon should avoid incising caruncles, which can lead to profuse haemorrhage. If these are incised inadvertently, they must be ligatured to avoid substantial blood loss. The incision should always be made over the greater curvature of the uterine horn, because this area has the fewest large blood vessels. The greater curvature runs between, and parallel to, rows of caruncles which are both visible and palpable through the uterine wall.

The membranes (allantochorion and amnion) are ruptured manually, and the calf's fetlocks grasped by the surgeon, exteriorised and passed to an assistant to facilitate delivery. Alternatively, sterile calving ropes or chains may be attached to the hind limbs and handed over to an assistant who initially pulls the calf in a dorso-lateral direction until the calf's pelvis emerges in the flank incision. Then lateral traction is applied, such that the calf is rotated and removed in a similar way to a per vaginam delivery of a calf in posterior longitudinal presentation. At the same time, the surgeon attempts to retain the uterus outside the abdomen, thereby minimising contamination of the abdominal cavity.

Exteriorisation of the pregnant horn can be difficult and is not always possible, for example when the uterus is firmly contracted (even when tocolytic drugs have been administered), or in cases of uterine torsion. A grossly oversized fetus and lack of physical strength may also make exteriorisation very difficult, if not impossible. In these cases, the incision of the uterus has to be made within the abdominal cavity, either because the uterus has become friable or is likely to be liable to damage by further manipulation. However, such an incision may lead to gross contamination of the abdomen with fetal fluids, which are unlikely to be sterile, particularly if dystocia is the indication for surgery. Furthermore, incision within the abdomen is often made more difficult by bouts of straining by the dam. This 'blind' incision should be made on the cranial aspect of the greater curvature of the pregnant horn by using a Roberts' embryotomy knife or a scalpel, in which case the surgeon's fingers shield the cutting edge. Often, it is impossible to make the incision long enough, and it is safer to make a small incision first, then one or both limbs of the calf are

grasped through the incision and pulled into the flank incision. While an assistant applies gentle traction to the calf, the uterine incision can be extended further.

A live calf should be immediately attended to by an assistant, whilst the surgeon examines the uterus, initially for the presence of a second fetus. In addition, any lacerations of the uterine wall should be noted and repaired. The fetal membranes should only be removed at the time of surgery if they are lying free within the uterus or can be readily detached, which is uncommon. Otherwise, they are returned to the uterine lumen and any protruding tags trimmed, so that these are not incorporated in the suture line of the uterine incision. This approach is justified on two grounds. Firstly, it should be assumed that if the fetal membranes can physically be separated, they will be expelled naturally and more completely by uterine contractions. Secondly, if deliberate detachment of the fetal membranes is attempted before they would normally separate and be expelled, then there may be haemorrhage or incomplete removal either of microvilli or of larger masses of placental tissue. It is common practice to place antimicrobial pessaries in the uterine lumen before final closure of the hysterotomy wound, but the value of these is questionable. If the fetal membranes are subsequently expelled naturally, so too will be the pessaries. If they are retained, then the antimicrobials can have no more than a minimal local action in the lumen and are probably ineffective in controlling deep infection.

#### *Calf in posterior presentation*

Adequate rotation of the uterus (if required) is a prerequisite for success (see below, under 'rotation of the calf'). Delivery of the calf through the abdominal incision is similar to that for a normal anterior longitudinal presentation. With the calf in posterior presentation, the head and fore limbs are situated in the uterine horn. Often these structures together are so bulky that it is difficult to get sufficient grip to elevate the pregnant horn and to bring it into or near the incision. The following technique is recommended: with the left hand, the digits of the calf's underlying (most ventral) fore limb are grasped from above and traction applied, so the tip of the uterine horn may be elevated high enough to bring the greater curvature into sight. An incision of about 15 cm long can now be made safely with the right hand. The next step is for the left hand to grasp the metacarpus through the incision. Because this grip is more firm, the tip of the uterine horn can be elevated enough to allow the incision in the greater curvature to be extended. The membranes are ruptured, and ropes or chains are applied to the fore limbs, which are handed over to an assistant who initially pulls the calf upwards. At the same time, the head is guided through the uterine incision. A finger and thumb grip in each orbit is often helpful in bringing the head through the uterine and abdominal incision. Once the head and shoulders are outside the flank incision, the calf is slowly extracted by lateral traction. Often, there will be a small amount of uterine fluid spillage into the abdomen, which is of little consequence when the fetus is alive or has just died.

Occasionally, the hind quarters of the calf may be positioned so far within the vagina, that retropulsion per vaginam by an assistant is sometimes necessary, after careful washing and lubrication of the exteriorised parts of the calf. The fact that many cows urinate immediately after removal of a presented fetus, suggests that urine has been retained because of urethral compression.

### *Rotation of the uterus*

If the tip of the pregnant horn (left or right) is located in the right lower quadrant of the abdomen, it will be necessary for the surgeon to rotate the uterus along its longitudinal axis (clockwise) to bring the calf's limbs to the flank wound, which can be rather difficult to achieve in case of a large fetus or a surgeon of small stature. However, it is important that the uterus is rotated, because it allows the pregnant horn to be exteriorised. The uterus should be incised as close to the tip of the horn as possible, not over a fetal limb that is in the body of the uterus. Incisions made in or near the body of the uterus usually can only be sutured within the abdominal cavity, which is extremely difficult.

There are two techniques to rotate the uterus, after which the tip of the pregnant horn should come within reach, and can then be exteriorised as described above:

1. Traction should be applied on a leg with the left hand, whilst pushing the dorsal aspect of the uterus away from the surgeon with the flat of the right hand. Alternatively, both hands should be put against and under the back of the calf (which is situated in the body of the uterus, against the greater curvature, and facing towards the surgeon). The uterus is then elevated and pushed over to the other side of the abdomen. A similar technique can be attempted, if the indication for caesarean operation was irreducible uterine torsion, to correct the torsion before the incision of the uterus is made. However, the uterine wall in these cases is often oedematous and friable; extreme care must be taken in order to avoid penetration of the wall with one or more fingers.
2. The surgeon's right hand is brought under the body of the uterus and is then positioned on the dorso-medial aspect of the tip of the pregnant horn. With the hand so positioned, the uterus is rotated about 90° by pushing and pulling the tip of the horn under the uterus, which, at the same time, is lifted and pushed toward the opposite side of the abdomen by the surgeon's fore arm and elbow.

### *Suturing the uterine incision*

The edges of the uterine incision are inspected for haemorrhage, particularly from the cotyledonary vessels. It is advisable to exteriorise both uterine horns before the genital tract begins to involute, which will facilitate inspection and repair of the wound. Large vessels that are bleeding profusely should be ligatured. The uterus is supported by an assistant or held using uterine forceps, keeping the entire uterine incision outside the abdominal incision, and the incision is sutured using absorbable suture material, such as chromic catgut (3 USP or 7 metric), polyglycolic acid and polyglactin 910. Catgut has advantages over synthetic suture materials, particularly when the uterus is friable because the latter have a 'cheese wire' effect. However, catgut causes greater tissue reaction, and thus is more likely to produce adhesions. Preferably, a large round-bodied needle and suture material for the uterus should be prepared prior to surgery.

Suturing should start at the cervical end of the uterine incision, because if the uterus starts to involute the cervix retracts into the abdomen before the ovarian end does so. Complete closure of the hysterotomy incision is critical to preserve future fertility of the dam. Adhesions between the incision site and surrounding organs or the body wall are associated with infertility following caesarean operation. A variety of suture patterns have been employed; all are continuous inverting patterns with the objective of creating a water-tight seal by apposing serosal surfaces, whilst causing the minimum of subsequent

adhesions and uterine scarring. The Utrecht method, which is a modified Cushing pattern that is turned to a 30-45° angle away from the incision, is commonly used these days. The suture should start approximately 2 cm above the upper end of the incision, using oblique bites so the knot is buried within a fold of the inverting tissue. Similarly, the continuous interlocking, inverting pattern is inserted using oblique bites; these should begin about 2 cm from the incision edge, but are inserted some distance back from the emerging previous bite. Each bite should exit the uterine tissue near the edge of the incision. It is important not to perforate the uterine wall (the needle should pass through, but remain within the tissue), and to pull each suture tightly following its insertion. This suture pattern approximates the peritoneal surfaces, while the wound edges are not inverted too much (uterine healing occurs across the wound edges, rather than on the opposed peritoneal surfaces). The final knot is buried in the same manner as the knot at the start of the suture line. If done correctly, there will be no leakage of uterine fluid and little, if any, exposed suture material. The advantage of this suture pattern is minimal adhesion formation following surgery. A single layer is sufficient if the uterine wall is healthy and the uterine contents are not septic. This pattern is particularly efficient if the uterine wall is flaccid during repair of the wound. Alternatively, a Lembert suture pattern can be used with the needle passing at right angles to the incision, or a Cushing pattern, where the needle passes parallel to the incision. Regardless of the suture pattern used, the rapidly involuting uterine wall will leave less tissue in each bite of suture material than at the moment of suturing, and this may loosen the suture. Many surgeons oversew the first suture with a second continuous pattern, particularly if the uterus is friable and in situations where the suture may tear through the tissues. A second inverting suture should also be used if leakage of uterine contents is a potential problem. Great care should be taken to avoid inclusion of the placenta in the suture line.

Once the uterine incision has been repaired and the uterus checked for tears, the surface should be cleaned with sterile gauze and/or Hartman's solution to remove blood clots and other debris. The uterus is then returned to its correct location within the abdomen, ensuring that there is no torsion of the genital tract. Oxytocin (20-40 IU) may be administered intramuscularly at this point to hasten uterine involution and expulsion of the placenta. However, uterine contractions induced by oxytocin may cause abdominal straining, which will make suturing of the flank incision more difficult. Often, it is better to wait until the surgery is completed. The abdominal cavity is inspected for large blood and fibrin clots, which should be carefully scooped out by hand. The administration of water-soluble antibiotic, such as crystalline penicillin, within the abdominal cavity is recommended by some surgeons, but not others. However, metronidazole should not be used because it is prohibited in food-producing animals in many countries, despite being recommended by some surgeons.

#### *Closing the flank incision*

The peritoneal cavity should be closed as quickly as possible to reduce the chance of bacterial contamination. Closure of the abdominal wall can be at the discretion of the surgeon. Chances of failure of the closure and subsequent herniation following incisions in the paralumbar fossa are minimal. Nevertheless, it is recommended that the abdominal flank incision is repaired in two layers: peritoneum and transverse abdominal muscle in the first, and internal and external abdominal oblique muscles in the second layer. A

simple continuous suture pattern is used, starting at the ventral commissure of the incision. Care is taken to appose the peritoneum and transverse abdominal muscle to avoid leakage of air from the abdominal cavity into the muscle layers following surgery. Air leakage is less likely following surgery on a recumbent animal, because less air is sucked into the abdomen during surgery. The amount of air within the abdomen can be reduced by an assistant compressing the ventral abdomen and flank immediately before closure of the dorsal aspect of the peritoneal incision. Sutures should be placed approximately 1cm apart using chromic catgut (3 USP or 7 metric). When suturing the layer of muscles, more tissue of the internal abdominal oblique muscle should be incorporated in each bite, i.e. the needle should enter the external abdominal oblique muscle closer to the edge of the incision than is the case for the internal abdominal oblique muscle. This technique will ensure good apposition of the two muscles. To reduce dead space between the suture layers, deeper bites with the suture can be made periodically into the deeper muscle layer, thus intermittently anchoring the suture into the underlying tissue. Antibiotics may be infused between the suture layers; approximately 250 mg/ml each of procaine penicillin G and dihydrostreptomycin as a mixture is commonly used. However, the value of this in preventing wound infection is debatable. Before closing the skin, it is advised to place several simple interrupted tension sutures wide and deep through the abdominal muscles, using chromic catgut.

The skin incision is closed in a standard manner (e.g. a simple interrupted horizontal mattress or cruciate pattern) using a cutting needle and non-absorbable suture material, such as sheathed monofilament nylon (3 USP or 6 metric). Moderate tension should be applied to the sutures to bring the wound edges into complete apposition, which will ensure a good seal and promote first-intention healing. In the case of infection, the most ventral suture can be removed to allow drainage and/or flushing of the wound. Although often described, the use of a continuous suture pattern, such as the Ford interlocking pattern, is not recommended by the author because of its associated risk of the entire suture line coming undone. Nowadays this risk is greatly increased with the majority of cows kept in loose housing systems, or not being housed at all.

## ***II: Lateral oblique approach***

An alternative to the left paralumbar fossa approach in the standing cow is the lateral or left oblique approach, which involves an oblique incision from caudo-dorsal to cranio-ventral, about 30-45° from vertical. The incision is started about 10 cm cranial and 10 cm ventral to the cranial aspect of the tuber coxae, extending cranio-ventrally to end about 3 cm caudal to the last rib. The advantages of an oblique incision are that the internal abdominal oblique and transverse abdominal muscles can be split in the direction of their respective fibres, and there is improved access to the gravid uterus. Potential disadvantages are incision of the circumflex iliac artery if the incision is extended too far caudo-dorsally and lack of anaesthesia if too far cranio-ventrally, when using paravertebral anaesthesia.

The abdominal wall incision should be closed in three layers, all in a simple continuous pattern. The peritoneum and transverse abdominal muscle are incorporated in the first layer, whereas the internal and external abdominal oblique muscles are sutured separately.

The lateral oblique approach allows better manipulation and exteriorisation of the uterus than the standard flank or paralumbar fossa approach, and has been suggested to be preferable when surgery must be carried out on the standing animal with a dead fetus.

### **III: Right paralumbar approach**

A right flank incision is uncommon; however, it is indicated if the left flank approach is obstructed by adhesions as a result of previous surgery. An approach from the right side may also be necessary in case of severe rumen distension or the presence of a large fetus in the right uterine horn. Access to the uterus is good, but the small intestines are difficult to retain within the abdomen (i.e. prolapse of the bowel through the incision is more likely) and they interfere with the surgery. Inadvertent incision of the digestive organs must be avoided when approaching the uterus from the right flank. In all other respects, completion of a caesarean operation through the right paralumbar fossa is identical to that from the left.

### **Post-Operative Care**

**The calf.** A live calf should be dried and the navel dressed with antiseptic immediately after delivery. Once surgery is completed, 2-3 litres of colostrum from the dam should be administered to the calf, using an oesophageal feeding tube if necessary. The dam should be introduced to the calf promptly, particularly in the case of a suckler cow and calf, to form a maternal bond.

**The dam.** The wound should be cleaned following surgery, but no wound powder, spray or antiseptics should be applied to normal skin incisions. The teats and udder should be examined, and oxytocin (20-40 i.u.) should be administered intramuscularly to stimulate further uterine involution, if not done so already during surgery. In addition, calcium borogluconate should be administered intravenously to mature dairy cows to prevent hypocalcaemia and facilitate uterine involution.

The degree of further aftercare required varies widely, depending on the indication of the surgery. Ideally, the dam should be confined for several days to allow close observation and reduce the opportunity for traumatic disruption of the abdominal wound. A non-steroidal anti-inflammatory drug (NSAID) should be considered, at least in cases of animals that have had severe dystocia, uterine torsion or uterine infection prior to surgery. If there is evidence of surgical shock, intravenous fluid therapy is indicated; 2-3 litres of hypertonic (7.2%) sodium chloride are particularly effective. This should be followed by 20-25 litres of tepid water given orally if the cow does not drink. Systemic antimicrobial therapy should be directed against the most common bacteria present in the post-partum uterus (i.e. *Arcanobacterium pyogenes*, *Escherichia coli*, *Fusobacterium* spp. and *Bacteroides* spp.), and should be administered for an appropriate period of time, usually 3-5 days, or until the fetal membranes are expelled. Appropriate choices are procaine penicillin G with or without dihydrostreptomycin, amoxicillin, ceftiofur or oxytetracycline.

The animal should be re-examined 24-48 hours after surgery and particular note of the rectal temperature, demeanour, appetite and faecal consistency should be noted. The

faeces are often dry and the cow mildly constipated following surgery. Pyrexia, depression, inappetence and diarrhoea may indicate peritonitis. If the fetal membranes have been retained, appropriate treatment should be instituted. Skin sutures should be removed no sooner than 3 weeks after surgery. In addition, a post-natal examination of the genital tract can be performed at this time because endometritis is more common following caesarean operation. Insemination should be delayed until >60 days post partum.

### **The Emphysematous Fetus**

While fetotomy is generally the preferred procedure to enable delivery of an emphysematous calf, a caesarean operation is indicated when obstetric manipulation or fetotomy is not possible. This may be because: a) the uterus is contracted around the swollen calf; b) there is little or no uterine fluid present; c) the cervix is incompletely dilated or is constricting again; or d) the uterus is friable and is therefore easily damaged. The veterinarian may also be inexperienced in performing a fetotomy.

Where there is an emphysematous fetus, the main aim of the caesarean operation is survival of the cow; maintenance of fertility is of relatively little concern because of the life-threatening nature of the condition. Because this is often a salvage operation, the welfare of the animal and cost to the owner are also important considerations. It is inappropriate to embark on a prolonged and costly caesarean operation (or fetotomy, for that matter) if the prospects for survival of the cow are poor. Hopeless cases or cases beyond the expertise and capabilities of the attending veterinarian should be recognised before the procedure is started, and the animal should be either humanely destroyed or expert assistance should be sought.

The most important rule in the management of an emphysematous fetus is not to panic. By the time the cow is presented, the question of how quickly the fetus is removed has little impact on the likelihood of the cow surviving. An emphysematous fetus is often associated with profound toxæmia and bacteraemia of the dam, resulting in fever, hypotension and shock. Therefore, it may be necessary to first provide supportive treatment for cardio-vascular stabilisation and management of shock, using intravenous fluids and non-steroidal anti-inflammatory drugs.

When the calf is emphysematous, exteriorisation of the gravid uterine horn becomes crucial in order to avoid contamination of the abdominal cavity with infected uterine contents. In the standing animal, complete exteriorisation is usually not possible and another approach should be used in which the uterus can be apposed more closely to the incision.

#### ***IV: Ventrolateral approach***

A ventrolateral incision is particularly indicated for the removal of an emphysematous fetus. The gravid horn can be exteriorised more easily, but the incision may be difficult to close because of the tension on most layers of tissue, and wound problems, such as breakdown and dehiscence or incisional hernia, often occur after surgery due to the limited holding strength of the fascia of this part of the abdominal wall.

The animal should be positioned in lateral recumbency, with the pregnant horn nearest the incision. The hind limbs are pulled caudally and the uppermost hind limb is abducted slightly to provide more room in case the incision needs to be extended. An oblique abdominal incision in the lower flank, starting from the flank fold dorsal to the attachment of the udder, is continued cranially, parallel to the ventral border of the ribs; it follows the imaginary line between the stifle joint and the umbilicus. Initially, the incision should be 30-40 cm long, but can be extended caudally towards the attachment of the hind limb or cranially parallel to the subcutaneous abdominal vein (milk vein). As a precaution, this major vessel should be identified and marked prior to the cow becoming recumbent as it often collapses in recumbent animals.

The skin and external sheath of the rectus abdominis muscle are incised. The rectus abdominis muscle fibres are then bluntly separated in the direction in which they run. The internal rectus sheath is very thin and its fibres are separated perpendicular to their orientation. The uterus lies directly underneath the incision and an attempt should be made to exteriorise the entire gravid horn. If this is not possible, the body wall should be pushed down and around the uterus. The uterus should be further isolated from the abdomen using drapes, such as clean towels or plastic sheeting. The uterine wall is then incised and the emphysematous calf (with or without placenta) withdrawn from the uterus. After the removal of a severely emphysematous fetus, the uterus is often noticeably ischaemic, of cardboard-like consistency and totally atonic.

The uterine incision should be closed in a double layer, preferably using the Utrecht method, thus providing a secure closure, which is less likely to leak uterine fluids during contraction and involution of the uterus. The surface of the uterus should be thoroughly cleaned with an isotonic saline solution, before returning it to the abdomen. The abdominal wall incision should be sutured in layers. The peritoneum and internal rectus sheath can be closed together. The rectus abdominis muscle should be sutured (if possible) in a continuous pattern. The most important layer is the external sheath of the rectus abdominis muscle because it has the most tensile strength; it is best closed in a single interrupted or vertical mattress pattern. The skin is closed in an acceptable manner. The advantage of the ventrolateral approach is that it gives good exposure of the uterus, even when it is friable, and it minimises the risk of uterine contents contaminating the abdominal cavity. However, repair of the abdominal muscle layers can be more difficult, particularly if the muscles are under tension and sutures may tear through the tissues. Loosening or releasing the uppermost hind limb will reduce tension and may facilitate closure of the abdominal incision. A surgical drain may be inserted during repair of the wound.

#### ***V: Ventral approach***

A ventral approach is not commonly used in the field because general anaesthesia or heavy sedation is required and respiratory function of the dam is compromised. However, the technique with the cow in dorsal recumbency gives excellent access to the uterus. Exteriorisation of the uterus is facilitated, while contamination of the abdominal cavity with septic uterine contents is reduced. Also, it may prove easier to extract the fetus from animals in dorsal recumbency; the surgeon, however, is forced to perform the surgery while in an uncomfortable position. Incisions in the ventral body wall are more likely than those in the paralumbar fossa to be complicated by post-operative hernias.

Consequently, strict attention to the fundamental principles of surgery is indicated to prevent or reduce the incidence of post-operative eventrations.

The abdominal wall is incised midway between the subcutaneous adominal vein and the midline (paramedian incision) or on the ventral midline. The incision is initiated at the level of the umbilicus and extended caudally to the cranial border of the udder. Non-absorbable suture material should be used for repair of all muscle layers of the incision because post-operative wound dehiscence has severe implications, including herniation. The ventral midline approach has the added advantage of greater holding strength of the linea alba.

#### ***VI: Low-flank approach***

With the cow in left lateral recumbency, the incision is made from approximately 15 cm below the transverse processes of the lumbar vertebrae, extending down to just above the subcutaneous abdominal vein. The three abdominal muscles should be sharply incised in the same direction. After opening the abdominal cavity, the cow is pushed up to a near sternal position, and the pregnant horn is rolled out of the abdomen onto a large plastic sheet that has been sterilised or disinfected previously. The uterus is incised, its contents removed and the incision closed using a double suture line. The flank incision should be closed as described for the left paralumbar fossa approach. Although this particular approach for the caesarean operation is not tried and tested, it may be a useful alternative technique in the field.

#### **Intra-Operative Management**

The emphysematous fetus presents unavoidable risks of peritoneal contamination, not least because its hair and hooves may already have been shed. In such cases, incision of the uterus is often followed immediately by the escape of gas and fetid fluid; parts of the fetus may be grossly swollen and crepitate on handling. The uterine wall is often tightly stretched, and intra-uterine manipulation can be difficult. Abdominal wall and uterine incisions of adequate length are therefore essential. Such a grossly swollen fetus often requires considerable traction, not only on limb snares but also with sharp or blunt hooks applied in the orbits and at appropriate points on the trunk or upper limbs to secure additional purchase. It may be necessary to incise deeply at several sites over the thorax and abdomen to release gas, and sometimes partially to eviscerate the fetus, before removal is possible. Incision of the fetal abdominal wall may also be necessary where there is ascites. In rare cases, the fetus simply cannot be removed from the uterus because it is impossible to make a uterine incision of adequate length; in such animals, fetotomy from the laparotomy site may be attempted.

#### **Success Rates and Complications of Surgery**

Fetal survival following caesarean operation partially depends on the indication for surgery. However, a calf mortality rate of 12% following caesarean operations has been reported, compared with 5% for control calvings.

Maternal survival rates following caesarean operation are high; most surveys report 90-98% dam survival. In a series of 1,134 operations performed principally for dystocia, an 88% maternal survival rate was reported, despite the fact that 37% of calves were dead at the time of surgery. Furthermore, 80% of cows survived even when an emphysematous fetus was present.

Complications associated with a caesarean operation are often due to difficulties encountered during: a) rotation of the uterus; b) exteriorisation of the pregnant horn; c) making the uterine incision; d) removal of the calf; and e) suturing of the uterine incision, and most of these difficulties can be anticipated. However, several complications have been reported to occur following a caesarean operation, including:

**Subcutaneous emphysema.** Air often leaks from the abdominal cavity into the subcutaneous tissues and muscle layers following surgery if the peritoneum is not closely apposed, causing emphysema. The condition is more common in animals that have tenesmus after surgery, usually as a consequence of dystocia, and can extend as far as the shoulders in some cases. Although unsightly, it has no significant detrimental effect on the animal and treatment is not required. Dependent on the volume of air, the tissues return to normal in 1-8 weeks.

**Metritis and retained fetal membranes.** Retention of the placenta occurs in 6-10% of cases of caesarean operation. Dystocia, twins, uterine torsion and fetal monsters are common indications for a caesarean operation; the procedure itself predisposes to retained fetal membranes. Removal of the membranes during surgery is rarely possible, but the placenta is normally expelled within 4-6 hours after surgery. However, if they are retained more than 24 hours after surgery, gentle attempts at removal can be made daily by exploration of the vagina only. Intra-uterine and intramuscular antibiotic can be administered, although most literature recommends no treatment in uncomplicated cases. Once the membranes have been expelled, usually as a necrotic mass after approximately 7-11 days, gentle lavage of the uterine lumen with 5 litres of warm, normal saline can be administered using a sterile wide-bore tube.

**Adhesions.** To date, no clinical research has documented any beneficial effect of any prophylactic treatment (e.g. lavage of the uterus, NSAIDs, intra-abdominal antibiotic) to prevent adhesion formation in cattle. Still, it is not uncommon for adhesions to develop following a caesarean operation. Neither the suture pattern (i.e. Utrecht method, Lembert or Cushing) nor the suture material (i.e. plain catgut, chromic catgut, polyglycolic acid or polyglactin 910) used to repair the uterine incision appears to be very important. However, the surgeon does seem to have the greatest influence on the number and severity of adhesions that occur. The surgeon's speed, skill and dedication are mentioned in the literature as being the best prevention against adhesion formation. It is crucial to obtain a good seal of the uterine incision, whenever possible, and to avoid excessive tissue handling, trauma, ischaemia and haemorrhage.

The use of synthetic absorbable suture materials, such as polyglactin 910 and polyglycolic acid, does not seem to offer any advantage with regard to the development of adhesions. However, from a surgical point of view, these materials have excellent handling qualities,

are more pliable than catgut, hold knots well, and do not fray. They also have a higher guarantee of uniform material quality compared with a biological product such as catgut. Besides the high cost of these synthetic suture materials, there is another important disadvantage. Due to the braided structure, there is more drag as it passes through tissue, which can lead to small tears, especially when the uterine wall is oedematous. Catgut on the other hand is more easily damaged by contact with the needle. This can cause the uterine suture to break, which would inevitably result in a severe peritonitis.

Nowadays, the trend amongst cattle surgeons is to use large-diameter (6 USP or 10 metric) plain catgut suture material for closure of the uterine incision. Although this material is more reactive than chromic catgut or the synthetic materials, it may actually result in fewer adhesions, possibly due to the time factor. With the abundant blood supply of the rapidly involuting uterus, the suture material is probably absorbed so quickly that adhesions have less chance to form compared with suture materials that remain in situ for longer periods of time. The knots are the last portion of the suture line to be absorbed, probably because cellular invasion is more difficult. Therefore, burying the knots in folds of uterine wall at both ends of the incision, as is achieved when using the Utrecht method, should always be the primary goal when suturing the uterus.

**Peritonitis.** Diarrhoea, pyrexia, inappetence and abdominal pain are the common presenting signs of peritonitis following a caesarean operation. Fortunately, the omentum and/or the use of antimicrobial therapy often limit the peritonitis. However, in many instances there are recurrent cycles of peritonitis and healing, leading to formation of extensive adhesions and chronic weight loss.

Inadequate repair of the uterine incision, particularly in the presence of a metritis, is the principal cause of post-operative peritonitis. However, in some cases, the peritonitis may already exist at the time of surgery. The incidence is increased in the case of a dead or emphysematous fetus, after severe dystocia, rupture of the uterus or presence of a fetal monster, and after spillage of infected uterine fluids into the abdomen during surgery. Spillage of small quantities of uterine fluid into the abdominal cavity appears to be of little consequence to the outcome of the caesarean operation if the fetus is alive or dead, but still fresh.

A variety of treatments have been suggested including parenteral antibiotics, intra-abdominal administration of antibiotic through the right flank, surgical lavage of the peritoneal cavity and intravenous fluid therapy.

**Wound dehiscence.** As many as 6% of animals may have complications related to dehiscence, abscess or seroma formation around the abdominal incision. Predisposing factors for wound dehiscence include inadequate asepsis, low abdominal incisions, trauma to tissues during surgery, environmental contamination, tenesmus, and a poor temperament of the animal after surgery. In addition, removal of skin sutures too early after surgery can lead to the incision line opening up; 3 weeks is a minimum period.

Serum-like fluid occasionally accumulates at the ventral aspect of the wound between the muscle layers if the dead space is not fully occluded; it will resolve spontaneously or can be drained surgically. In other cases, there may be formation of an abscess. In most instances, this can be lanced, drained and irrigated as a granulating wound and second

intention healing will follow. Antibiosis is usually not required, but may be necessary if there is pyrexia.

**Nerve paralysis.** Cows that are recumbent during surgery have the risk of temporary or permanent peroneal nerve injury. Animals that have been in lateral recumbency on a hard surface may suffer from radial paralysis. In addition, a number of cows may have sustained trauma to the obturator nerve during dystocia prior to caesarean operation. More often, though, femoral paralysis is encountered as a 'stretch injury' in large calves, mainly of beef breeds following hip or stifle lock during parturition.

**Fractures.** The dam may sustain a fracture whilst attempting to rise after surgery. However, more common is a long-bone fracture or growth-plate separation of the calf during attempts to correct dystocia prior to caesarean operation.

**Post-partum haemorrhage.** Haemorrhage from the abdominal incision is usually limited, although dependent on the haemostatic concern of the surgeon. However, haemorrhage from the uterine incision can be considerable and in some cases fatal, if the cotyledonary vessels are disrupted. Occasionally, the haemorrhage may be minimal at surgery, but may progress in the 24 hours following operation. Furthermore, in sporadic cases the large vessels in the broad ligament may be damaged causing considerable blood loss. Prevention is by careful incision of the uterus, supporting the genital tract adequately during surgery, and close attention to haemostasis. Treatment of severe haemorrhage is by a blood transfusion. In addition, 20-30 IU oxytocin may be administered repeatedly to stimulate uterine contraction in an attempt to reduce uterine haemorrhage.

**Blackleg.** Although rare, it has been reported that 0.5% of cases died suddenly within 24 hours of surgery as a result of blackleg, with lesions located distant from the operative site.

### **Post-Operative Fertility**

Under normal circumstances, the three main goals of the caesarean operation in cattle are: a) survival of the cow; b) survival of the calf; and c) maintenance of post-operative productivity, which implies not only the maintenance of body condition and an acceptable level of lactation, but also the ability to conceive again and sustain a developing fetus to term. Numerous data have been published on fertility rates after a caesarean operation, but their significance is qualified by the fact that many animals are culled without being inseminated or served again. In a number of these studies, the percentage of cows that subsequently conceived post operatively ranged from 48-80%, with a mean value of 72% for 2,368 animals, compared with 89% after normal calvings. Another study reported that 60% of 1,857 cows and heifers that had a caesarean operation were subsequently inseminated, and 74% of these eventually conceived with an average of 1.8 inseminations per conception. However, there was an increased incidence of abortion, hydrallantois and failure of the cervix to dilate at the next parturition, probably due to scar tissue in the uterine wall. Although the calving interval is increased in cows

following a caesarean operation compared with normal calvings, the principal cause of economic loss is the higher culling rates. Interestingly, in the latter study the calving-to-first insemination interval was similar between caesarean and control cows, but the calving-to-conception interval was 18 days longer. Reduced fertility may occur as a consequence of increased incidence of retained fetal membranes and endometritis, uterine adhesions that hinder involution, adhesions that affect the ovary or uterine tube, and reduced endometrial tissue competence. In addition, there is an increased risk of abortion during subsequent pregnancy, possibly as a result of scar tissue formation within the uterine wall, limiting expansion of the uterus and/or nutrition of the fetus.

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