Veterinary Record Open

OPEN ACCESS

Retrospective analysis of iatrogenic diseases in cattle requiring admission to a veterinary hospital

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To cite: Sala G, Boccardo A, Fantinato E, *et al*. Retrospective analysis of iatrogenic diseases in cattle requiring admission to a veterinary hospital. *Veterinary Record Open* 2019;**6**:e000254. doi:10.1136/vetreco-2017-000254

Received 12 September 2017
Revised 23 November 2018
Accepted 21 January 2019

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ABSTRACT

Iatrogenic diseases in veterinary medicine are often related to malpractice or lack of skill. For this retrospective study, 4262 clinical records of cattle admitted to the veterinary teaching hospital of the University of Milan between 2005 and 2017 were analysed, and 121 cases (2.8 per cent), referred for an iatrogenic-related disease, were selected. The findings showed that iatrogenic diseases were more often caused by farmers (92.6per cent) than by bovine practitioners (7.4 per cent). Iatrogenic diseases were caused mainly by the improper administration of drugs (43.0 per cent), forced extraction during calving (19.8 per cent), forced milk or colostrum feeding, which was often performed by awkward administration using a nipple bottle (14.9 per cent) or by oral oesophageal tubing (15.7 per cent). Moreover, farmers often performed medical, nursing and zootechnical procedures without adequate training. The role of the practitioner is fundamental in farmer education. Clinicians, especially in some professional branches such as neonatology, should not delegate medical procedures to untrained farmers. Effective tutoring and good communication with farmers play a key role in dairy herd health and consequently in public health. This then can lead to a decrease in improper drug administration, the prevention of antibiotic resistance and the reduction of treatment costs.

INTRODUCTION

Iatrogenic diseases are disorders induced by preventable human errors. In human medicine, these conditions are widely described in a variety of disciplines, as there is increasing focus on reducing complications and improving patient safety,[1 2] and also in insurance issues related to hospitalisation. In veterinary medicine, small animal practice is becoming increasingly similar to human medicine, and each branch is entrusted to a specialist with care quality playing a primary role.[3] Thus, understanding the causes of iatrogenic diseases in small animal practice is fundamental in order to standardise reliable and accurate methods to detect and prevent errors during veterinary practice.[4 5]

However, in large animal practice, the literature is lacking and often limited to illustrative case reports or case series. A retrospective analysis of balling gun-induced trauma in cattle was reported by Mann and others.[6] Similarly, some cases of central or peripheral neurological diseases induced by mishandled drug injections have been described both in calves and adult cattle.[7–10]

Poulsen and McGuirk[11] reported that, in their practice, the misuse of oral oesophageal feeders is the most common cause of neonatal aspiration pneumonia. Several studies have demonstrated that iatrogenic fractures in newborn calves are frequently caused by forced extraction, applied by farmers during calf delivery.[12–14] An outbreak of *Anaplasma marginale* infection associated with the vaccination of a herd containing a few infected animals using the same hypodermic needle has been described in Italy.[15] Lucena and others[16] found that iatrogenic diseases accounted for 0.16 per cent of cattle mortality in southern Brazil.

Traditionally, iatrogenic diseases have been associated with physicians or medical procedures, which were however always carried out by qualified staff. In farm animal practice, the involvement of other stakeholders should be considered in addition to the role of the practitioner. In fact, although there is no guarantee that the stock person has received an appropriate training for procedures such as drug administration, disbudding and so on, he or she has been reported as the person who most frequently carries them out, both in Europe and the USA.[17–19]

The aim of this study was to systematically analyse the characteristics of iatrogenic diseases occurring on-farm in a population of cattle referred to a veterinary teaching hospital in northern Italy, in order to evaluate the causes, types of errors and kinds of diseases that determined the admission to the hospital.

MATERIALS AND METHODS

Selection criteria

This retrospective study was performed on cattle admitted to the Clinic for Ruminants and Swine of the University of Milan. Case selection considered 4262 clinical records related to the period between February 2005 and June 2017. Recorded history was the main criterion to select clinical cases: during patient admission, animal owners or practitioners reported that the animal got sick after a procedure performed on the animal. Clinical examination, laboratory data or image diagnostic recorded on clinical charts were used to confirm the selection. Only patients referred for on-farm iatrogenic diseases were included in the study, whereas patients with incomplete records or nosocomial diseases that occurred during hospitalisation were excluded. A three-stage sampling process was adopted to select clinical cases: initially records were independently screened by two veterinarians (GS and EC); positive records were than cross-compared and reviewed by an experienced veterinarian (DP) who discussed the selected cases with the veterinarian who admitted the animal. A further control was performed by a pathologist (PR and EF) who reviewed the cause of death of the animals submitted to necropsy. Details of patients and liable persons are not relevant for understanding this manuscript and have been removed from this paper to ensure anonymity.

Procedures

For the clinical record analysis, the following variables were considered: year of admission, breed, sex, age, weight, reason for the procedure inducing the iatrogenic damage (defined as case history), wrong or inappropriate procedure responsible for the iatrogenic disease (defined as error), person potentially responsible (defined as person), description of iatrogenic damage (defined as diagnosis) and outcome.

The variables, age, person and outcome were first categorised to get a better representation of the data. Regarding age, patients were categorised into three classes: (1) ≤30 days, (2) 31 days–1 year and (3) >1 year. Regarding person, we considered the veterinary practitioner or the farmer (animal owner or employee) as being potentially responsible. Regarding outcome, we classified the event as recovery (full recovery or clinical improvement for animals discharged with deficits compatible with zootechnical productions) or end of life (death or euthanasia). Classification of case history, error and diagnosis was delayed until after the analysis of the clinical records.

Statistical analysis

Descriptive statistics were performed; continuous variables are reported with median, minimum and maximum values, and categorical variables are reported with frequencies as number and per cent. The number of per-year clinical cases was considered as a proportion of the total number of proyear hospitalised cattle, and expressed as a per cent, in order to examine the linear trend in iatrogenic damage onset over the last 12 years (figure 1).

The effect of age, case history, error, diagnosis and person on outcome was analysed by using logistic regression. All five variables were considered for inclusion in the final model using backward stepwise regression. ORs and 95 per cent CIs are reported. A p value of <0.05 was

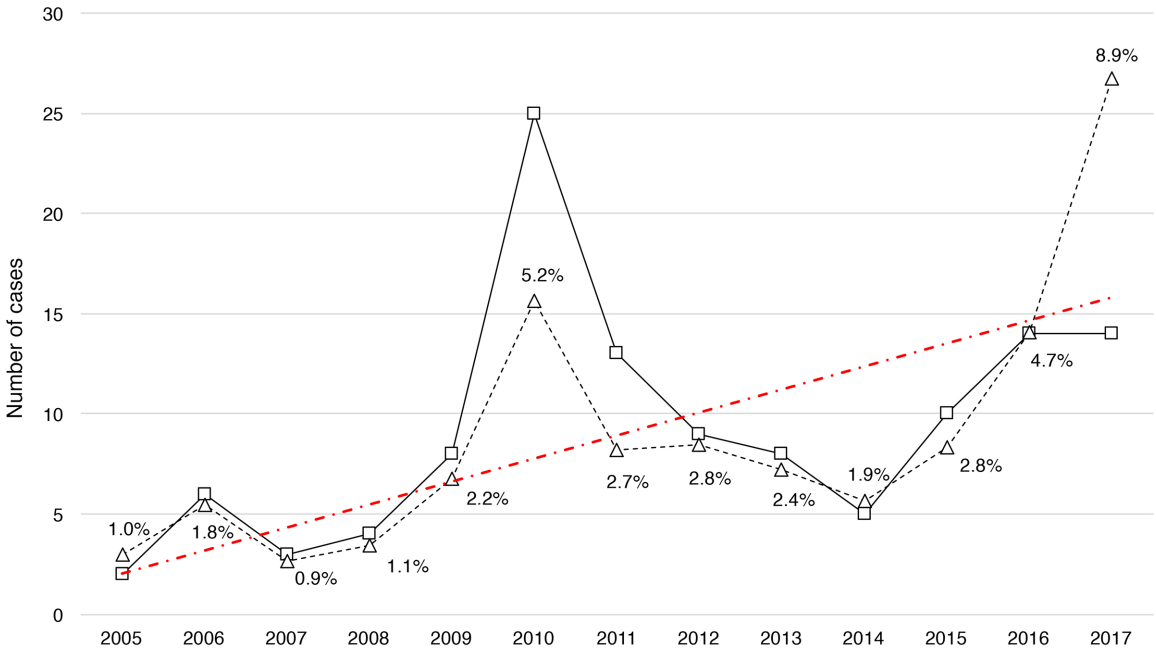

Figure 1 Annual distribution of iatrogenic diseases. Data are reported either as number of cases per year (solid line) or as a percentage of total admitted bovine animals (dashed line). In 2010, the high number of iatrogenic cases was related to the simultaneous admission of 18 calves from the same herd with zinc-oxide poisoning. Red dashed line: linear trend related to the percentage of animals admitted due to iatrogenic diseases.

considered significant for all analyses. Analyses were performed using IBM SPSS statistics for Windows (V. 24.0).

RESULTS

From 4262 examined clinical records, 121 cases were selected (2.8 per cent). The annual distribution of iatrogenic disease was not uniform from 2005 to 2017 (figure 1). The breed distribution in this study was: 102 Holstein Friesian (84 per cent), 9 crossbred beef breeds (7 per cent), 4 Brown Swiss (3 per cent), 2 Limousine (2 per cent) and 4 other breeds (3 per cent). One hundred and two animals were females (84 per cent) and 19 were males (16 per cent). Regarding age, 95 cases (79 per cent) were 30 or less days old, 9 ranged between 31 days and 1 year (7%) and 17 were older than 1 year (14 per cent). The median age of patients was 10 days. The weight ranged between 30 kg and 650 kg with a median of 40 kg.

According to the clinical record analysis, case history was divided in 12 categories (table 1). Neonatal calf diarrhoea in 31 per cent of calves was the most common recorded historical reason for the procedure inducing the iatrogenic damage in calves. The second most frequent event inducing iatrogenic disease was calving due to injuries resulting from an improper operation during normal or difficult delivery in 21 per cent of calves. Administration of colostrum (13 per cent), anorexia/asthenia in calves (11 per cent), postpartum disorders in cows (ketosis, metritis, mastitis, suspected left abomasal displacement and puerperal collapse [10 per cent]) and bovine respiratory disease (6 per cent) represented other frequent reasons for erroneous procedures. Rarely were iatrogenic diseases a consequence of dehorning/disbudding (3 per cent), or a consequence of an attempted treatment of a generic enteritis (2 per cent), ruminal bloat (2 per cent) or a fracture in a newborn calf (1 per cent). Finally, iatrogenic diseases occurred during claw trimming (1 per cent) and artificial insemination oestrus (1 per cent).

The errors responsible for iatrogenic diseases were summarised by 11 categories (table 1). The most common error was improper administration of drugs in 43 per cent of cases, and this category included cases where drug administration was not compliant with the leaflet instructions, especially regarding dosage and route of administration, with cases where injection was performed by untrained staff. Another frequent error was represented by forced extraction during calving (20 per cent) related to excessive strength applied during delivery or an erroneous use of obstetrical instruments, especially a mechanical calf puller. In this category, cases of mandibular or limb fractures, peripheral nerve damage (brachial plexus paresis) and joint luxation were included. The use of oral oesophageal tubing (16 per cent) for the administration of drugs, milk or colostrum accounted for 16 per cent of errors, and this was followed by an awkward use of

Table 1 Categories with number (N) and per cent (%) of cases for the variables case history, error, person, diagnosis and outcome

	N (%)
Case history	
Neonatal calf diarrhoea	38 (31.4)
Calving	25 (20.7)
Administration of colostrum	16 (13.2)
Anorexia/asthenia	13 (10.7)
Postpartum disorders	12 (9.9)
Bovine respiratory disease	7 (5.8)
Dehorning/disbudding	3 (2.5)
Enteritis	2 (1.7)
Ruminal bloat	2 (1.7)
Claw trimming	1 (0.8)
Fracture	1 (0.8)
Oestrus	1 (0.8)
Total	121 (100)
Error	
Improper administration of drugs	52 (43.0)
Forced extraction	24 (19.8)
Oral oesophageal tubing	19 (15.7)
Awkward use of a nipple bottle	18 (14.9)
Excessive thermal application	2 (1.7)
Artificial insemination	1 (0.8)
Closure of horn stumps with resin	1 (0.8)
Rectal examination	1 (0.8)
Restrain	1 (0.8)
Ruminal puncture	1 (0.8)
Sterner & Grymer toggle-pin suture	1 (0.8)
Total	121 (100)
Person	
Farmer	112 (92.6)
Vet	9 (7.4)
Total	121 (100)
Diagnosis	
Aspiration pneumonia	32 (26.4)
Drug overdose/toxicosis	22 (18.2)
Fracture	21 (17.4)
Peripheral nerve damage	20 (16.5)
Phlebitis	7 (5.8)
Peritonitis	4 (3.3)
Spinal cord damage	4 (3.3)
Pharyngeal perforation	3 (2.5)
Frontal sinusitis	2 (1.7)
Joint luxation	2 (1.7)
Oesophageal foreign body	2 (1.7)
Abscess/phlegmon	1 (0.8)

Continued

Table 1 Continued

	N (%)
Tetanus	1 (0.8)
Total	121 (100)
Outcome	
Recovery	70 (57.9)
End of life (death or euthanasia)	51 (42.1)
Total	121 (100)

a nipple bottle in 15 per cent of cases. Less frequent errors were represented by excessive thermal application during disbudding (2 per cent), closure of horn stumps with resin after dehorning (1 per cent), rectal examination (1 per cent), restraint (1 per cent), ruminal puncture (1 per cent) and Sterner & Grymer toggle-pin suture (1 per cent).

The person was identified as the veterinarian in only 7 per cent of cases and the farmer in the remaining 93 per cent.

Concerning diagnosis, observed iatrogenic damage was grouped into 13 categories (table 1). Aspiration pneumonia (27 per cent), drug overdose/toxicosis (18 per cent), fractures (17 per cent) and peripheral nerve damage (17 per cent) were the most frequently diagnosed diseases. In particular, cases of aspiration pneumonia were mainly induced by milk or colostrum administration using an oral oesophageal feeder or by forced feeding in calves with weak or absent suckle reflex, sometimes using bottles with an enlarged hole nipple. Drug overdose/toxicosis included: 18 cases of zinc oxide chronic poisoning due to prolonged oral administration in calves suffering from neonatal diarrhoea, as suggested to the animal owner by a pig-breeder neighbour; one case of xylazine poisoning, due to the erroneous administration of a 20 per cent concentrated formula, performed by a vet attempting to treat a fractured calf; and one case of aminoglycoside poisoning due to the prolonged administration of high dosages of a 10 per cent gentamicin formulation to a calf affected by *Escherichia coli* neonatal diarrhoea, instead of a 5 per cent formulation. The last two cases were due to the use of various antibiotics and to bicarbonate excess in cases of neonatal calf diarrhoea. Fractures were generally observed in newborn calves, as a result of vigorous assisted delivery. In the category of peripheral nerve damage, a large number of cases were induced by erroneous intramuscular injection of antibiotics close to the forelimb or hindlimb nerves, especially fluoroquinolones, instead of the recommended subcutaneous or intravenous route of administration. An intramuscular injection of antibiotics into both gluteal muscles, performed on a dairy cow in a milking parlour, induced a bilateral sciatic nerve injury and a fatal case of downer cow syndrome. One case of the subcutaneous administration of 500 ml calcium borogluconate, during the postpartum period, near to the scapular region, was also included in this category as it caused a dramatic inflammation involving the axillary region and the brachial plexus. Less recurrent diagnoses consisted in: phlebitis (6 per cent), peritonitis (3 per cent), spinal cord damage (3 per cent), pharyngeal perforation (3 per cent), frontal sinusitis (2 per cent), joint luxation (2 per cent), oesophageal foreign body (2 per cent), abscess/phlegmon (1 per cent) and tetanus (1 per cent). Iatrogenic spinal cord damage was attributed to discospondylitis or spinal epidural abscesses as a consequence of deep intramuscular injection too close to the cervical vertebrae. One phlebitis case due to an awkward intravenous injection performed in the mammary vein resulted in serious damage involving the udder. The oesophageal foreign body cases were a result of the animals swallowing the devices during oral oesophageal tubing.

Therapy produced a positive outcome classified as recovery in 58 per cent of cases (full recovery in 61 cases and clinical improvement in 9 cases) and a negative outcome classified as end of life in 42 per cent of cases (death or euthanasia). Table 2 shows the association between history, error, liable person, diagnosis and outcome and reports specific episodes related to one or a few animals.

The final statistical model included the following variables: age, case history and error (table 3). Person and diagnosis were not retained in the model (p=0.3 and 0.1, respectively). In calves younger than 30 days, the probability of dying due to an iatrogenic disease was higher than other age classes (OR 3.051). For case history, the probability to have a bad outcome is significantly greater for postpartum disorders (OR 1.080). Regarding errors, oral oesophageal tubing was the class with the highest death probability (OR 1.922).

DISCUSSION

In human medicine, studies regarding medical errors are regularly published in order to better understand preventable adverse events and subsequently promote better quality care.[1 20] Veterinary medicine has also started to pay attention to this issue but limited to small animal practice.[21]

Regarding large animal practice, iatrogenic diseases are often reported as single case reports or case series; research methods have yet to be standardised. The present study attempts to classify iatrogenic disease features into variables and subclasses in order to permit an objective analysis.

In cattle, a retrospective study performed by Lucena and others,[16] in a 44-year period in southern Brazil, found that 0.16 per cent of deaths were linked to iatrogenic diseases. The current study found that iatrogenic diseases accounted for 2.8 per cent of the total causes of veterinary hospital admissions. The lower iatrogenic injuries percentage of Lucena and others may be related to the extensive Brazilian silvopastoral system that usually results in a decrease in human interaction and,

Table 2 Association between history, error, person, diagnosis with numbers of cases and outcome (N recovered (*N end of life))

Neonatal calf diarrhoea	38
Improper administration of drugs	32
Farmer	
Drug overdose/toxicosis†	21 (*9)
Peripheral nerve damage	9 (*4)
Phlebitis	1
Spinal cord damage	1 (*1)
Oral oesophageal tubing	1
Farmer	
Aspiration pneumonia	1
Awkward use of a nipple bottle	5
Farmer	
Aspiration pneumonia	5 (*2)
Calving	25
Improper administration of drugs‡	1
Farmer	
Peripheral nerve damage	1
Forced extraction	24
Farmer	
Fracture	20 (*11)
Peripheral nerve damage	2 (*1)
Joint luxation	1 (*1)
Vet	
Fracture	1 (*1)
Administration of colostrum	16
Oral oesophageal tubing	10
Farmer	
Aspiration pneumonia	9 (*4)
Pharyngeal perforation	1
Awkward use of a nipple bottle	6
Farmer	
Aspiration pneumonia	6 (*4)
Anorexia/asthenia	13
Improper administration of drugs	2
Farmer	
Peripheral nerve damage	2 (*2)
Oral oesophageal tubing§	4
Farmer	
Aspiration pneumonia	4 (*1)
Awkward use of a nipple bottle	7
Farmer	
Aspiration pneumonia	7 (*2)
Post-partum disorders	12
Improper administration of drugs	7
Farmer	
Peripheral nerve damage	1 (*1)
Phlebitis	6
Oral oesophageal tubing	3
Farmer	
Pharyngeal perforation	2
Vet	
Oesophageal foreign body	1
Rectal examination¶	1
Vet	
Peritonitis	1
Sterner & Grymer toggle-pin suture**	1
Vet	
Peritonitis	1
Bovine respiratory disease	7
Improper administration of drugs	7
Farmer	
Peripheral nerve damage	3 (*2)
Spinal cord damage††	2 (*1)
Abscess/phlegmon	1
Vet	
Peripheral nerve damage	1
Dehorning/disbudding	3
Excessive thermal application	2
Farmer	
Frontal sinusitis	2
Closure of horn stumps with resins‡‡	1
Vet	
Tetanus	1 (*1)
Enteritis	2
Improper administration of drugs	2
Farmer	
Peripheral nerve damage	1
Spinal cord damage§§	1
Ruminal bloat	2
Oral oesophageal tubing	1
Farmer	
Oesophageal foreign body	1
Ruminal puncture	1
Vet	
Peritonitis	1
Claw trimming	1
Restraint	1
Farmer	
Joint luxation	1 (*1)
Fracture	1
Improper administration of drugs	1

Continued

Table 2 Continued

Vet	
Drug overdose/toxicosis¶¶	1 (*1)
Oestrus	1
Artificial insemination	1
Vet	
Peritonitis***	1 (*1)

*Number of deceased animals within the group.
†Eighteen cases of chronic zinc oxide poisoning, two cases of excessive sodium bicarbonate administration in calves with neonatal diarrhoea, resulting in severe metabolic alkalosis, and one case of gentamicin poisoning.
‡Perinatal intramuscular antibiotic administration (enrofloxacin) for non-clarified reasons, close to the shoulder, caused paresis of the plexus brachialis.
§Milk administration by oral oesophageal tube or feeder.
¶Accidental rectal perforation.
**Localised hepatitis/peritonitis induced by an attempted Sterner & Grymer surgery: the first toggle fixed the left liver lobe to the ventral abdominal wall, while the second inserted toggle got lost in the abdomen itself. The cow survived after surgical removal of the toggles via laparotomy and omentopexy.
††Spinal epidural abscesses.
‡‡The application of cyanoacrylate glue on horn stumps, after the removal of the horns in a bull, caused anaerobic conditions allowing *Clostridium tetani* growth.
§§Discospindylitis induced by intramuscular enrofloxacin administration close the cervical column.
¶¶Mistook a 2 per cent xylazine hydrochloride concentrated formula for a 20 per cent formulation.
***The practitioner accidentally perforated the vagina and bowel with an artificial insemination gun during insemination.

consequently, to a reduction in the likelihood of iatrogenic injuries; moreover, their analysis considers only cattle referred for necropsy.

Figure 1 shows that there has been a gradual increase in the percentage of cattle referred for iatrogenic diseases in the last few years. This could be due to the economic crisis, which has meant that farmers have had fewer financial resources to consult practitioners, especially for animals in unproductive periods, such as calves. Young calves (≤30 days) indeed have the highest probability of being affected by iatrogenic damage, and the probability of dying due to an iatrogenic disease is three times higher than other age classes (OR 3.051). These data further underline the importance of communication in improving management and health in dairy farms,[22 23] especially in professional branches as neonatology which, as has emerged from this study, pay the highest price.

Another interesting finding of this paper is that the errors performed by farmers can be grouped into three main events (use of drugs, administration of colostrum or milk and extraction of calves during delivery). However, errors performed by veterinarians are heterogeneous and are often caused by oversight.

According to the statistical analysis, the improper use of drugs was the most frequent error (52 cases; 43.0 per cent), perpetrated especially by farmers (50 cases). It should be recalled that, in compliance with the law, in food-producing animals, some procedures can be directly carried out by farmers; the farmer or his or her working staff can therefore administer antimicrobials following a veterinary prescription.[18] Unfortunately, according to the results of this study, these procedures are often performed by untrained personnel, resulting in severe or fatal events. Regarding the improper use of drugs, we found a considerable number of drug toxicities that were not related to adverse effects (22 cases, 18.2 per cent). Most of these cases were related to chronic zinc poisoning. The literature reports several cases of electrolyte toxicosis,[24] mainly related to erroneous dosage. In the reported zinc poisoning case, zinc oxide administration was performed without a veterinary consultant. In the remaining cases, the dose administered by the veterinarian (one case) and animal owner (three cases) was excessive, leading to toxicosis. Concerning the erroneous route of drug administration, in the present study, peripheral nerve damage represented the most frequent iatrogenic disorder. In the literature, intramuscular drug injection was the major cause of peripheral nerve and muscle lesions in cattle.[8] Our results showed that peripheral nerve damage was, in most cases, due to an intramuscular drug injection and also for tissue-damaging formulations where the intramuscular route was not recommended, as with some fluoroquinolones. In order to save time and money for veterinary services, some farmers also often administered a high volume of solutions subcutaneously (saline, calcium and glucose solution), which should be administered intravenously. These events were associated with subcutis infections or phlegmons. However, farmers' attempts to perform intravenous injections/administration of drugs in the mammary vein led to severe damage involving the subcutis of the abdominal wall or even the udder. These results underline the need for a better communication between practitioners and farmers, in order to reduce these errors.

Our results highlight that the forced administration of colostrum or milk in calves, both via a nipple bottle and oral oesophageal tube, was an important cause of aspiration pneumonia (32 cases; 26.4 per cent). Poulsen and McGuirk[11] stated that the most common causes of aspiration bronchopneumonia are the misure of oral oesophageal feeders and the improper training of on-farm personnel in placing the feeder into the oesophagus. In the last few years, the use of oral oesophageal tubes has increased on farms to ensure the timely feeding of an appropriate volume of good quality colostrum in order to improve the passive transfer of immunity.[25] As observed in this study, oral oesophageal tubing has also been unfortunately adopted by farmers in administering milk to calves with weak or absent suckle reflex but neglecting the real cause of anorexia/asthenia, which

Table 3 Final logistic regression model showing the effect of 3 variables on outcome with p values, ORs and CIs

	Model adaptation criteria	Effect				
Variable	**Likelihood log –2**	**χ^2**	**df**	**P value**	**ORs**	**95% CIs**
Age	70.390	6.325	2	0.042		
≤30 days				0.041	3.051	0.928 to 10.036
31 days–1 year				0.066	0.406	0.021 to 1.415
>1 year				0.455	0.422	0.130 to 1.371
Case history	82.549	18.485	9	0.030		
Neonatal calf diarrhoea				0.990	0.998	0.477 to 2.088
Calving				0.269	1.747	0.733 to 4.162
Administration of colostrum				0.598	1.372	0.483 to 3.900
Anorexia/asthenia				1.000	0.858	0.265 to 2.776
Postpartum disorders				0.028	1.080	0.112 to 10.450
Bovine respiratory disease				1.000	1.029	0.221 to 4.801
Dehorning/disbudding				1.000	0.686	0.061 to 7.776
Enteritis				1.000	1.372	0.084 to 22.464
Ruminal bloat				0.640	0.457	0.046 to 4.526
Other				0.315	0.412	0.026 to 1.625
Error	76.506	12.441	5	0.029		
Improper administration of drugs				0.868	0.930	0.480 to 1.801
Forced extraction				0.179	0.588	0.212 to 0.966
Oral oesophageal tubing				0.035	1.922	0.411 to 3.560
Awkward use of a nipple bottle				0.862	0.961	0.343 to 2.694
Excessive thermal application				0.373	0.490	0.061 to 7.776
Other				0.998	1.372	0.266 to 7.079

The referent category of the dependent variable for the final logistic regression model is the outcome 'recovery'.

can be induced by underlying disorders, such as respiratory distress syndrome or neonatal calf diarrhoea.[26 27] Moreover, we found that damage caused by oral oesophageal tubing led to a death risk that was 1.922 times higher than other error classes. Although Poulsen and McGuirk[11] suggest that the proper training of on-farm personnel is important to ensure the correct placement of the feeder in the oesophagus and to deal with potential problems related to milk/colostrum reflux, we believe that this frequently misused technique should be considered a strictly medical or professional veterinary nursing procedure. If poorly executed, it can lead to iatrogenic damage or fatal events (aspiration pneumonia, pharyngeal perforation and oesophageal foreign body).

According to the statistical analysis, forced extraction at calving was another frequent error (24 cases, 19.8 per cent) performed especially by farmers (23 cases). In the literature, iatrogenic fractures in calves, due to forced extraction during dystocia, represent the most common cause of fracture in newborn calves. Fractures and joint dislocations were more common when mechanical traction was applied during difficult calving.[14 28] We have shown that the most frequent consequence of forced extraction, especially using a calf puller, was a fracture (21 cases), followed by peripheral nerve damage (two cases) and joint luxation (one case). These findings seem to indicate that some farmers are not aware of the conditions or procedures requiring veterinary intervention and perform obstetrical procedures without the required competence. Farmer education and careful procedural decision making by the veterinarian could reduce dystocia-related injuries and perinatal deaths in calves.[14]

In human medicine and in small animal practice, iatrogenic diseases in most cases involve medical management,[20 29] while in large animal practice, farmers need to be considered. In our experience, farmers often consult different practitioners with different expertise for different health issues but take responsibility themselves for general farm management. Bovine practitioners should also avoid delegating specific procedures to untrained staff, especially in neonatology. However, the factors influencing farmers' problem-solving decisions are usually complex and are influenced by individual attitudes,[30] previous experience in solving problems, the time available to conduct extracare activities,[31] the level of herd management,[32] cost–benefit analyses[6] and by poor communication between veterinarians and farmers.[33 34] Interactions among these factors can influence farmers'

decisions to call the practitioner.[35] The veterinarian's role is fundamental in farmer education, motivation and problem solving.[33] Communication strategies are required to support disease control programmes[36] in order to improve animal and public health. A decrease in unnecessary drug administration may result in a reduction in treatment costs and antibiotic resistance risks.

Training on-farm personnel correctly is important to improve or prevent common errors raised in our study, represented by drug administration, oral oesophageal tubing, the mishandled use of a nipple bottle and perinatal trauma from assisted delivery.

Our study was carried out in Italy, where in contrast with other EU countries, there is no university-led undergraduate training for veterinary nursing or healthcare assistants. The role of healthcare assistance goes alongside the role of veterinary practitioner.[37] This assistance could improve the veterinarian's work and the communication between practitioner and farmer, as they work closely with farmers. Properly trained undergraduate personnel and qualified farm staff are fundamental to prevent errors, especially in providing skilled supportive care for sick animals and medical, obstetrical or zootechnical treatments under veterinary supervision.

Contributors All authors conceived and designed the study. GS, EC and DP carried out the selection of clinical cases; all authors analysed the data and wrote the paper, and VB performed the statistical analysis.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Ethics approval Publication of data was approved by the ethical committee of the University of Milan (approval number 47/2017, November 28, 2017).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement All data relevant to the study are included in the article

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