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Incidence of surgical site infection in dogs undergoing soft tissue surgery: risk factors and economic impact

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ABSTRACT

Objectives To determine (1) the incidence of surgical site infection (SSI) in patients undergoing soft tissue surgery at a veterinary teaching hospital and to study (2) and describe the main risk factors associated with SSI and (3) assess the economic impact of SSI.
Design Prospective cohort study.
Setting Veterinary teaching hospital.
Participants 184 dogs undergoing soft tissue surgery during a 12-month period (October 2013 to September 2014).
Primary outcome measure Surgical site infection.
Results Out of the 184 patients analysed, SSI was diagnosed in 16 (8.7 per cent) patients, 13 (81.3 per cent) were classified as superficial incisional infection, 2 (12.5 per cent) as deep incisional infection and 1 (6.3 per cent) as organ/space infection. The administration of steroidal anti-inflammatory drugs (P=0.028), preoperative hyperglycaemia (P=0.015), surgical times longer than 60 minutes (P=0.013), urinary catheterisation (P=0.037) and wrong use of the Elizabethan collar (P=0.025) were identified as risk factors. Total costs increased 74.4 per cent, with an increase in postsurgical costs of 142.2 per cent.
Conclusions The incidence of SSI was higher than the incidence reported in other published studies, although they were within expected ranges when a surveillance system was implemented. This incidence correlated with an increase in costs. Additionally new important risk factors for its development were detected.

INTRODUCTION

Surgical site infection (SSI) is one of the most common surgical complications. These infections are responsible for an increase in morbidity, mortality, prolonged hospital stay, increased costs and a negative impact on the emotional state of the owner.[1–7]

In human medicine, a number of studies evaluate SSI in hospital and state-wide. However, that is not the case in veterinary medicine, where the development of this type of studies is relatively recent. These investigations have been conducted mostly in North America and estimate an incidence of SSI of 3.0–6.6 per cent.[3 4 7–9]

The SSI surveillance systems used in these studies differ from those used in human medicine, since some are retrospective, some are not performed by trained personnel, some do not use a system of definitions that is up to date and some do not differentiate between inflammation and infection, making it difficult to obtain an accurate incidence and the detection of risk factors.

Despite the small number of studies and the early stages of implementation of SSI surveillance systems in veterinary medicine, the hypothesis of this study was that the incidence of SSI would be higher than that estimated in human medicine and that the risk factors associated with SSI would be similar to those existing in human medicine.

For all of these reasons, the objectives of this study were to determine the incidence of SSI in patients undergoing soft tissue surgery at a veterinary teaching hospital and to study and describe the main risk factors associated with SSI and to evaluate their economic impact.

MATERIALS AND METHODS

A prospective cohort study was performed. Canine patients that underwent surgery at a veterinary teaching hospital performed by the Soft Tissue Surgery Service were the population investigated in this study. Both male and female canine patients of all ages that required soft tissue surgery during the study period and who met the inclusion criteria were included in the study. Inclusion criteria included: soft tissue surgery carried out between October 2013 and September 2014. Dental, ophthalmological, orthopaedic and neurological procedures were excluded.

The data were collected from the clinical management software used in the hospital (Qvet) and the surgical and anaesthetic records. The SSI was classified as described in table 1 and other variables were classified as general variables (age, gender, reproductive

Table 1 Definition of SSI

Location of infection	Criteria
Superficial SSI	► Within 30 days. ► It affects skin and subcutaneous tissue. ► The patient meets at least one of the following criteria: purulent drainage, positive culture, at least one of the following signs or symptoms of infection: pain or tenderness, localised swelling, redness or heat, the surgeon deliberately opens the incision unless negative culture. ► Medical diagnosis of superficial SSI.
Deep SSI	► Within 30 days. ► It affects deep soft tissue to the incision. ► The patient has one of the following: purulent drainage, spontaneous dehiscence deep incision or deliberate opening by the surgeon when the patient has at least one of the following symptoms: local pain, fever, abscess or other evidence of deep infection found in direct examination, reoperation or histopathological or radiological study. ► Medical diagnosis of deep SSI.
Organ/space SSI	► Within 30 days. ► It affects any other part of the anatomy to open or manipulated during surgery incision. ► The patient presents at least one of the following: purulent discharge, positive culture, abscess or other evidence of infection involving an organ or space found by direct examination, reoperation or by histopathological or radiological study. ► Medical diagnosis of organ/space SSI.

SSI, surgical site infection.

status, breed, underlying pathology, administered treatments and number of follow-up appointments), presurgical variables (type of intervention, degree of contamination of the surgical procedure, type of surgical scrub of staff and patient, clipping performed under anaesthesia and laboratory abnormalities), personnel variables (identity of surgical, anaesthetic and auxiliary personnel, number of staff present in the operating room, undergraduate students involved in the surgical procedure), anaesthetic variables (American Society of Anesthesiologists (ASA) status classification, maintenance anaesthetic agent, locoregional blocks, existence of hypotension and hypothermia episodes), surgical variables (anaesthesia and surgery duration, use of drains, skin suture pattern, use of electrosurgery, scheduling nature of procedure, type of sterilisation system programme, surgical room where procedure was performed, reintervention) and postoperative variables (hospital stay, administration of postoperative antibiotics, blood products transfusion administration, feeding tube, urinary catheterisation and use of Elizabethan collar).

An active surveillance system was used. Patients were checked up at the hospital by trained personnel on days 5 and 10 after surgery. The researcher did the final follow-up visit over the phone on day 30 after surgery. SSI was diagnosed and classified using the definition system[1010] described in table 1.

Categorical variables are expressed as rates per cent and measurable variables are expressed as mean (sd) and 95% CI. Categorical variables were compared by the Pearson chi-squared test with continuity correction or Fisher's exact test when at least 25 per cent of values showed an expected cell frequency below 5. Quantitative variables were compared by the Student's *t* test after evaluation of normal distribution test (Kolmogorov-Smirnov) and equality of variances. Quantitative variables without normal distribution were analysed by Mann-Whitney U test. All statistical analyses were performed with the use of SPSS software (V.17.0), and all reported probability values were two sided. Significance was assumed at the 5 per cent level ($P<0.050$).

The economic impact was analysed following the same methods used previously in both human and veterinary medicine models. Costs were classified as presurgical costs, surgical costs and postsurgical costs. The difference between the SSI group and the healthy group was expressed by mean difference and percentage increase.

RESULTS

A total of 184 surgical procedures were included in the study, of which 16 (8.7 per cent) developed SSI. Classification of SSI by type of surgery and type of infection is represented in table 2. The percentage of females (56.5

Table 2 Classification of SSI			
	Superficial n (%)	**Deep n (%)**	**Organ/space n (%)**
Global 16 (8.7%)	13 (81.3)	2 (12.5)	1 (6.3)
Type of surgical procedure			
Dermatological	4 (80)	1 (20)	0 (0)
Gastrointestinal	3 (75)	0 (0)	1 (25)
Endocrine	0 (0)	0 (0)	0 (0)
Spleen	1 (100)	0 (0)	0 (0)
Ear	0 (0)	0 (0)	0 (0)
Peritoneal	1 (50)	1 (50)	0 (0)
Reproductive	4 (100)	0 (0)	0 (0)
Respiratory	0 (0)	0 (0)	0 (0)
Urinary	0 (0)	0 (0)	0 (0)

SSI, surgical site infection.

per cent) was slightly larger than that of males (43.5 per cent). The incidence in castrated patients was lower (21.7 per cent) compared with intact animals (78.3 per cent). The mean age was 72.7 months and the mean hospital stay length was 1.6 days long.

As to the general variables, differences were not found in the following variables: age (P=0.505), gender (P=0.302), breed (P=0.339) and reproductive status (P=0.334). Other variables such as underlying pathology (P=0.323) (respiratory diseases, neurological disease, kidney disease, leishmania disease, liver disease, endocrinopathy, coagulopathy, infection, tumour and heart disease) administered treatments (P=0.455) (antihistamines, chemotherapeutics) and laboratory abnormalities (P=0.821) were analysed and no association with SSI was found. However, administration of steroidal anti-inflammatory drugs was associated with SSI (P=0.028) (table 3).

The type of surgical scrub used by staff and the patient, removal of hair and changes in cell blood count were not related to SSI. In the biochemistry blood work, presurgical hyperglycaemia increased the risk of developing SSI (P=0.015) (table 4).

Table 5 summarises the anaesthetic variables, and no significant relationship was found for any of them (ASA status, hypotension, hypothermia, maintenance anaesthetic agent or locoregional block). The number of people in the operating room, undergraduate students present and staff who performed the intervention did not act as risk factors in this analysis (table 6).

All surgical variables were summarised in table 7. No association was found between the development of SSI and the degree of contamination, presence of drains, electrosurgery, scheduling, type of sterilisation system programme, operating room, reintervention and skin suture. The duration of intervention did not prove to be a risk factor, however, the duration categorised in more than 60 minutes was related to the development of SSI (P=0.013).

Finally, postoperative variables such as antibiotic therapy, antibiotic choice, administration of blood products and hospital stay (total, preoperative and postoperative) were not related to the development of SSI. The presence of urinary catheterisation (P=0.037) and the misuse of the Elizabethan collar during the early postoperative period (P=0.025) were identified as risk factors (table 8). The use of the Elizabethan collar was evaluated in 73 animals (out of 184 total animals included in the study).

Table 3 General variables					
	Infection	**No infection**			
Variable	**n (%)**	**n (%)**	**RR**	**95% CI**	**P value**
Demographic					
Gender					
Male	5 (6.3)	75 (93.8)	1		
Female	11 (10.6)	93 (89.4)	1.7	0.6 to 4.7	0.302
Reproductive status					
Intact	11 (7.6)	133 (92.4)	1		
Castrated	5 (12.5)	35 (87.5)	1.6	0.6 to 4.5	0.334
Age	83.4 (49.8)	71.7 (46.6)	11.7	–12.5 to 35.9	0.505
Treatments					
No	11 (7.0)	147 (93.0)	1		–
Steroidal anti-inflammatory	4 (26.7)	11 (73.3)	**3.8**	1.0 to 1.1	**0.028**
Antihistamines	0 (0.0)	2 (100.0)	–	–	–
Chemotherapeutics	1 (14.3)	6 (85.7)	2.1	0.3 to 13.7	0.417

Bold value significantly associated with SSI. p-value < 0.050
RR, risk ratio.

Table 4 Presurgical variables

Variable	Infection n (%)	No infection n (%)	RR	95% CI	P value
Laboratory abnormalities					
Hyperglycaemia (>112 mg/ml)					
No	13 (7.3)	164 (92.7)	1		–
Yes	3 (42.9)	4 (57.1)	**5.8**	(2.1 to 15.9)	**0.015**
Surgical variables					
Patient's surgical scrub					
Physiological saline	1 (6.7)	14 (93.3)	1		–
Alcohol	15 (8.9)	154 (91.1)	1.3	0.2 to 9.4	1.000
Staff's scrub					
Chlorhexidine	1 (2.6)	37 (97.4)	1		–
Alcohol	15 (10.3)	131 (89.7)	3.9	0.5 to 28.6	0.199
Intraoperative lavage					
No	10 (8.0)	115 (92.0)	1		–
Yes	5 (8.9)	51 (91.1)	1.1	0.4 to 3.1	0.779
Local	1 (33.3)	2 (66.7)	4.1	0.7 to 22.9	0.238
Removal of hair					
Anaesthetised	15 (8.4)	163 (91.6)	1		–
Awake	0 (0.0)	3 (100)	–		–
No	1 (33.0)	2 (66.7)	3.9	0.7 to 21.1	0.244

Bold values significantly associated with SSI. p-value < 0.050
RR, risk ratio.

The mean cost of a surgical procedure was €459.4. The mean presurgical cost was €94.4, the mean surgical cost was €111.3 and the mean postsurgical cost was €253.9. SSI surgical procedures showed a mean cost of €752.3 and non-SSI surgical procedures showed a mean cost of €431.2. The increase in mean cost in SSI surgical procedures was €321.1 (74.4 per cent increment compared with the non-SSI surgical procedures). Differences were not found in presurgical and surgical costs; however, postsurgical costs suffered a high increase in patients

Table 5 Anaesthetic variables

Variable	Infection n (%)	No infection n (%)	RR	95% CI	P value
ASA status					
I	3 (7.9)	35 (92.1)	1		
II	5 (8.6)	53 (91.4)	1	0.9 to 1.2	1
III	2 (5.6)	34 (94.4)	1.4	0.2 to 8.0	1
IV	5 (10.2)	44 (89.4)	0.8	0.2 to 3.0	1
V	1 (33.3)	2 (66.7)	0.2	0.0 to 1.6	0.271
Hypotension (<60 MAP)					
No	9 (7.5)	111 (92.5)	1		
SI	7 (10.9)	57 (89.1)	1.5	0.6 to 3.7	0.431
Hypothermia (<37°C)					
No	7 (8.5)	75 (91.7)	1		
Yes	9 (8.8)	93 (91.2)	1	0.4 to 2.6	0.552
Mild (37°C–35°C)	7 (7.4)	87 (92.6)	0.9	0.3 to 2.4	0.503
Severe (<35°C)	2 (25)	6 (75)	2.9	0.8 to 11.8	0.181

ASA, American Society of Anesthesiologists; MAP, Mean Arterial Pressure; RR, risk ratio.

Table 6 Surgical staff

Variable	Infection n (%)	No infection n (%)	RR	95% CI	P value
Surgeon					
4	1 (2.9)	34 (97.1)	1		–
1	2 (5.1)	37 (94.9)	1.7	0.2 to 18.9	1
2	5 (13.9)	31 (86.1)	4.8	0.6 to 39.5	0.199
3	7 (14.0)	43 (86.0)	4.9	0.6 to 38.0	0.133
5	1 (4.2)	23 (95.8)	1.4	0.1 to 22.2	1
Assistant					
3	1 (4.5)	21 (95.5)	1		–
No assistant	2 (4.7)	41 (95.3)	1	0.1 to 10.7	1
2	2 (16.7)	10 (83.3)	3.6	0.4 to 36.4	0.279
4	4 (8.9)	41 (91.1)	2	0.2 to 16.5	1
5	7 (11.3)	55 (88.7)	2.5	0.3 to 19.0	0.674
Anaesthesiologist					
3	2 (3.5)	55 (96.5)	1		–
1	2 (9.5)	19 (90.5)	2.7	0.4 to 18.1	0.292
2	2 (5.6)	34 (94.4)	1.6	0.2 to 10.7	0.639
4	10 (14.3)	60 (85.7)	4.1	0.9 to 17.8	0.039
Assistant veterinary technician (AVT)					
1	4 (7.0)	53 (93.0)			
No AVT	3 (10.7)	25 (89.3)	1		
2	3 (7.1)	39 (92.9)	1.5	0.4 to 6.4	0.679
3	6 (10.5)	51 (89.5)	1	0.2 to 4.3	1
Students					
No	7 (9.7)	65 (90.3)	1		–
Yes	7 (10.4)	60 (89.6)	1.1	0.4 to 2.9	0.887
People, n*	9.7 (2.9)	9.8 (3.7)	0.1	–1.9 to 1.8	0.296

*Data are expressed as mean (sd) and mean difference.
RR, risk ratio.

that developed SSI (€321.0 higher than non-infected patients, €225.7, which means an increment of 142.2 per cent). When postsurgical costs were analysed according to the type of SSI, the mean cost of superficial SSI was found to be €452.4, deep SSI €852.4 and organ/space SSI €1160.

DISCUSSION

The SSI incidence obtained in this study was greater than the incidence estimated by previous studies (3.0–6.6 per cent),[4 8 9 11] and this may be due to several reasons. First of all, the current study reported a higher proportion of contaminated and dirty surgical procedures compared with other previously published studies. In addition, the surveillance system used may also be responsible for the differences detected. In fact, the current study used standardised and up-to-date definitions[12] and that probably allowed a better detection of infections. On the other hand, all patients were checked up at the hospital by qualified personnel, which could also determine a better detection rate. In fact, an underestimation of SSI in primary care centres without specialised personnel has been described in human medicine.[9] Given these differences, it is important to emphasise that patients need to be checked up by qualified personnel. Additionally, where this check-up may not be performed by qualified personnel, awareness should be raised in primary care centres about the importance of SSI and the need to refer these patients to more sophisticated facilities.

In human medicine, the SSI is the most common of all nosocomial infections (16.0 per cent of total infections)[12] being its overall incidence of 5.0 per cent.[13] In the region where this study was performed, the data published in 2012 by the surveillance system of healthcare-associated infections reported an incidence of 3.9 per cent.[14] However, the incidence obtained in studies conducted in the country where the study was performed in the 1990s during the early stages of implementation of

Table 7 Surgical variables

Variable	Infection n (%)	No infection n (%)	RR	95% CI	P value
Degree of contamination					
Clean	8 (7.9)	93 (92.1)	1		–
Clean-contaminated	3 (8.6)	32 (91.4)	1.1	0.3 to 3.8	1
Contaminated	3 (8.3)	33 (91.7)	1.1	0.3 to 3.8	1
Dirty	2 (16.7)	10 (83.3)	2.1	0.5 to 8.7	0.287
Duration (minutes)*					
Anaesthesia	142 (50.8)	112.9 (51.5)	29.1	2.6 to 55.6	0.92
Surgery	86.5 (35.5)	64.1 (40.8)	22.4	1.5 to 43.2	0.87
Duration of surgery (categorised)					
<60 minutes	3 (3.4)	86 (96.6)	1		
≥60 minutes	13 (13.7)	82 (86.3)	**4.1**	1.2 to 13.8	**0.012**
Drains					
No	15 (8.6)	160 (91.4)	1		
Yes	1 (11.1)	8 (88.9)	1.2	0.2 to 8.8	0.567
Electrosurgery					
No	4 (4.8)	80 (95.2)	1		
Yes	12 (12.0)	88 (88.0)	2.5	0.8 to 7.5	0.083
Scheduling					
Elective	11 (7.5)	136 (92.5)	1		
Urgency	5 (13.5)	32 (86.5)	1.8	0.7 to 4.9	0.323
Sterilisation system programme					
Textile—instrumental	15 (8.5)	161 (91.5)	1		
Cauchos	0 (0.0)	3 (100)	–		
Quick	1 (20.0)	4 (80.0)	2.3	0.4 to 14.5	0.374
Operating room					
2	2 (6.7)	28 (93.3)	1		
1	12 (7.9)	140 (92.1)	1.2	0.3 to 5.0	1
3	1 (100)	0 (0.0)	–		
Induction room	1 (100)	0 (0.0)	–		
Reintervention					
No	14 (8.1)	159 (91.9)	1		
Yes	2 (18.2)	9 (81.8)	2.2	0.6 to 8.6	0.246
Skin suture					
X/U suture					
No	14 (8.1)	158 (91.9)	1		
Yes	2 (16.7)	10 (83.3)	2	0.5 to 8.0	0.28
Simple suture					
Yes	0 (0.0)	14 (100)			
No	16 (9.4)	154 (90.6)	–	–	0.615
Subcuticular suture					
No	2 (5.0)	38 (95.0)	1		
Yes	14 (9.7)	130 (90.3)	1.9	0.5 to 8.2	0.529
Continuous suture					
No	13 (8.4)	141 (91.6)	1		
Yes	3 (10.0)	27 (90.0)	1.2	0.4 to 3.9	0.728

Continued

Table 7 Continued

Variable	Infection n (%)	No infection n (%)	RR	95% CI	P value

Bold values significantly associated with SSI. p-value < 0.050
*Data are expressed as mean (sd) and mean difference.

Table 8 Postoperative variables

Variable	Infection n (%)	No infection n (%)	RR	95% CI	P value
Antibiotic therapy					
Not recommended and unmanaged	3 (5.2)	55 (94.8)	1	–	
Recommended and administered	10 (10.1)	89 (89.9)	1.9	0.6 to 6.8	0.375
Not recommended and administered	3 (11.1)	24 (88.9)	2.1	0.5 to 10.0	0.377
Recommended and unmanaged	0 (0.0)	0 (0.0)	–	–	
Transfusion					
No	14 (7.8)	165 (92.2)	1		
Yes	2 (40.0)	3 (60.0)	5.1	1.6 to 16.7	0.061
Albumin					
No	16 (8.7)	167 (91.3)	–	–	
Yes	0 (0.0)	1 (100)			
Packed red cells					
No	15 (8.3)	166 (91.7)	1		
Yes	1 (33.3)	2 (66.7)	4.0	0.8 to 21.4	0.240
Plasma					
No	16 (8.7)	167 (91.3)	–	–	
Yes	0 (0.0)	1 (100)			
Whole blood					
No	15 (8.2)	168 (91.8)	–	–	
Yes	1 (100)	0 (0.0)			
Catheter (other than intravenous)					
No	12 (7.4)	150 (92.6)	1		
Yes	4 (18.2)	18 (81.8)	2.5	0.9 to 6.9	0.106
Urinary catheterisation					
No	12 (7.1)	156 (92.9)	1		
Yes	4 (25.0)	12 (75.0)	**3.5**	1.3 to 9.6	**0.037**
Feeding tube					
No	16 (9.1)	160 (90.9)	–	–	
Yes	0 (0.0)	8 (100)			
Elizabethan collar					
Yes	4 (8.9)	41 (91.1)	1		
No	9 (32.1)	19 (67.9)	**3.6**	1.2 to 10.6	**0.025**
Hospital stay	**Infection**	**No infection**	**MD**	**95% CI**	**P value**
Hospital stay*	2.0 (3.3)	1.6 (2.5)	0.4	−0.9 to 1.7	0.459
Hospital stay presurgical*	0.3 (0.9)	0.4 (1.1)	0.1	−0.6 to 0.5	0.885
Hospital stay postsurgical*	1.7 (2.6)	1.9 (0.2)	0.4	−0.6 to 1.4	0.331

Bold values significantly associated with SSI. p-value < 0.050.
*Data are expressed as mean (sd) and mean difference.
MD, mean difference; RR, risk ratio.

SSI surveillance system in human medicine ranged from 9.3 to 9.7 per cent.[15 16] These data are similar to those obtained in the current study and it may be the reflection of the current stage of development of this surveillance system in the veterinary teaching hospital where the study was carried out. Therefore, these results may be considered an indication that the implementation of SSI surveillance systems in the future may help reduce the incidence of SSI. As for the risk factors studied, the degree of contamination of the surgical procedure has been widely studied in human medicine, and its involvement in the development of SSI has been solidly proven. In veterinary medicine there is only one study[4] that proved this association between dirty surgery and the development of SSI. However, the current study did not find an association between the degree of contamination of the surgical procedure and the development of SSI. This difference could be due to the fact that the classification used in human medicine is not suitable to properly assess veterinary patients. In fact, the results of the current study are similar to those reported by Vasseur *et al*[8] in a study performed on a veterinary population.

Regarding the existence of concomitant endocrine disease in the present study, an association with the development of SSI was not found. In veterinary medicine, only one study has proved the association between concurrent endocrine disease and a greater risk of suffering SSI.[3] In human medicine, on the other hand, the consensus task force for surveillance of SSI considers that conditions such as diabetes or cancer could be potential triggers for the development of SSI.[17] However, this association is difficult to assess in veterinary medicine due to the low proportion of surgical patients with endocrine disorders.

An association was observed between treatment with corticosteroids and the development of infection, an association that had not been described in a veterinary study before. This result could be explained by the effect caused by these drugs on the immune system leading to the development of immunosuppression. Eugster *et al*[4] evaluated the effect of immunosuppressive drugs and found no association between their administration and the occurrence of SSI. This difference with the results of the current study may be due to the fact that this study evaluated all drugs as a whole and not individually. On the other hand, results in human medicine are controversial. In fact, Engquist *et al*[18] observed a significant increase in the risk of suffering SSI in patients treated with corticosteroids, however Cruse and Foord[19] did not.

Similarly, preoperative hyperglycaemia has been found to be a risk factor. Previous studies on the role that biochemistry abnormalities may play in the development of SSI have not been carried out in veterinary medicine. However, in human medicine a number of studies have investigated the involvement of hyperglycaemia in the development of SSI. In fact, it has been proven that hyperglycaemia causes a reduction in diapedesis and phagocytic activity, therefore reducing the destruction ability of intracellular bacteria by leucocytes. As such, hyperglycaemia has been identified as a risk factor for the development of SSI in human medicine.[20–22]

The risk of infection according to the ASA classification was also analysed. The results of the present study showed that ASA classification was not a risk factor for developing SSI. These results are similar to those reported by Eugster *et al*.[4] However, in human medicine ASA classification is considered a proven risk factor for development of SSI by the Consensus Supervision of Surgical Wound Infection.[17] In fact, Garibaldi *et al*[23] showed the independent predictive power of ASA classification in a prospective study of 1852 patients.

As for the mean surgery time in both patients with and without SSI development, no differences were found between the two groups. However, when surgery time was categorised as under or over 60 minutes, the risk of developing SSI was larger in those surgical procedures that took more than 60 minutes. This finding is similar to the results obtained by other studies published in the veterinary literature that conclude that intervention time acts as a risk factor for the development of SSI.[3 4 8 11 24] Additionally, procedure duration in human medicine has been showed to be a risk factor for the development of SSI.[25]

The involvement of anaesthetic complications such as hypotension and hypothermia in the development of SSI is controversial. The present study found no relationship between the development of SSI and the existence of anaesthetic complications. In veterinary medicine there have been two recent studies evaluating the relationship between anaesthetic complications and development of SSI and their results defer with those obtained in the present study. In fact, these two studies conclude that hypotension[8 9] acts as a risk factor for the development of SSI. In human medicine, it is well known that hypotension, hypothermia and hypoxia contribute to the development of tissular hypo-oxygenation. Additionally, tissular hypo-oxygenation has been shown to be a risk factor in the development of SSI by numerous studies.[26–32] As a result, most guidelines recommend maintaining optimal tissue oxygenation at all times.[33] In veterinary medicine, further studies of this relationship are needed in order to obtain adequate scientific evidence.

All patients in the current study received preoperative chemoprophylaxis following the recommendations published in human[12 22 33 34] and veterinary medicine[9 35 9] guidelines, regardless of the degree of contamination of the surgical procedure. However, it has to be emphasised that the only available guidelines in veterinary medicine are the result of the extrapolation of recommendations from human guidelines.[9 12 34–36] In fact, in human medicine the use of preoperative chemoprophylaxis has been widely studied and its administration is based on the degree of contamination of the surgical intervention. As such, the use of antibiotic therapy is indicated in all proceedings that are categorised as clean-contaminated and contaminated. However, its use in interventions that are considered clean is controversial both in human and veterinary medicine. In fact, its use should be based on certain conditions such as the duration of the surgical intervention. Eugster *et al*[4] showed that preoperative use of chemoprophylaxis, even in clean procedures, acts as a protective factor against the occurrence of SSI. For this reason, the decision was made to administer preoperative antibiotics to all the patients of our study.

The administration of antibiotic therapy in the postoperative period was also evaluated in the present study and no benefit was found in the continuation of chemoprophylaxis more than 24 hours postoperatively. Practice guidelines in human medicine recommend[12] the interruption of postoperative antibiotics 24 hours after the end of procedures that are classified as clean. The only available studies that evaluate postoperative chemoprophylaxis in veterinary medicine have been performed in patients that underwent orthopaedic procedures. These studies concluded that the administration of postoperative antibiotic therapy acts as a protective factor.[6 7 37 38] However, this could be explained by the fact that there are no studies that evaluate surgical procedures other than orthopaedic ones and these surgical interventions, although considered clean, are characterised by a high incidence of SSI. In human medicine, the use of postoperative antibiotics in clean procedures is not contemplated. In fact, a number of studies have concluded that the continuation of this treatment more than 24 hours postoperatively provides no benefit against the development of SSI and may even contribute to the occurrence of antimicrobial resistance.[39–43]

No association was found between the placement of neither urinary catheter nor feeding tube with the development of SSI. However, when urinary catheterisation was analysed separately it proved to be a risk factor in the development of SSI. This finding has not been discussed previously in veterinary medicine. However, it could be explained by the proven association between the development of urinary tract infections (UTI) and the placement of urinary catheters.[44] In fact, the microorganisms responsible for the development of UTIs could easily be involved in the colonisation of surgical wounds.

Regarding the use of Elizabethan collar, an association was found between the lack of its use and the development of SSI. This phenomenon could be explained by the existence of certain degree of self-mutilation in veterinary patients when the healing surgical wound is not protected. As a result, the oral bacteria present in the mouth of dogs would directly contact the surgical site leading to the development of SSI. Many textbooks recommend the use of Elizabethan collar in the early postoperative period until the surgical wound is completely healed.[45 46] However, no previous published study had proven this relationship.

An added value of this study to veterinary medicine is the estimated economic impact of SSI that had only been previously evaluated by one single study.[47] In fact, the current study showed that the development of SSI entailed an increase of 74.4 per cent in the final cost of infected surgical procedures. It is important to highlight that the cost of the procedure itself was not considered when calculating the cost associated with the development of SSI. In fact, the great variability of procedures and their associated costs could have masked the true costs added by SSI. If costs were analysed separately, no difference was found between presurgical and surgical costs of healthy patients and those suffering from SSI. This is primarily due to the fact that these costs do not depend on the development of SSI, but rather on the underlying disease and the type of surgical procedure that the patient requires. However, postsurgical costs increased 142.2 per cent in infected patients. This increase is mainly due to the need for a greater number of follow-up appointments, the cost of additional treatment, as well as the performance of culture and antibiotic sensitivity tests. Those patients that required a second intervention to correct the consequences of SSI presented higher postsurgical costs, since a second intervention implied an additional increase in costs due to longer hospital stays and additional treatment. Additionally, the current study showed that postsurgical costs gradually increase depending on the type of infection. Thus, higher cost occurred in organ/space infections due to the therapeutic requirements of this type of infection which are much more invasive and expensive. Therefore, avoiding surgical infections is vital to preserve the patient's overall health status and to avoid unnecessary expenses. In fact, the implementation of surveillance and control systems for SSIs could reduce the economic costs and improve the service offered to patient and owner.

In summary, the implementation of SSI surveillance systems is necessary for the detection of its incidence as well as of the risk factors associated with its development. They would provide information that would allow the implementation of prevention and control measures that would help reduce infection rates and associated costs.

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Contributors JE-R designed data collection tools, monitored data collection for the whole trial, wrote the statistical analysis plan, cleaned and analysed the data, and drafted and revised the paper and he gave final approval of the version to be published MDM-R analysed the data, cleaned and analysed the data, and drafted and revised the paper and she gave final approval of the version to be published VS designed data collection tools, analysed the data and drafted and revised the paper and she gave final approval of the version to be published MRB designed data collection tools, monitored data collection for the whole trial, and revised the draft paper and she gave final approval of the version to be published GO-D wrote the statistical analysis plan, monitored data collection for the whole trial, and revised the draft paper and he gave final approval of the version to be published. He is guarantor.

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