Bacterial contamination of suction tips used during surgical procedures performed on dogs and cats

Catherine Sturgeon, BVetMed; Anne I. Lamport, BA; David H. Lloyd, BVetMed, PhD; Peter Muir, BVSc, PhD

Objective—To determine prevalence of bacterial contamination of surgical suction tips.

Sample Population—Surgical tips used during 44 surgical procedures performed on 42 dogs and 2 cats.

Procedure—Surgical procedures were classified into 1 of 3 categories according to degree of bacterial contamination of the surgical site (clean, clean-contaminated, contaminated). Two sets of suction apparatuses were used for test and control suction tips. Test tips were used normally to suction blood and fluid, whereas control tips were placed on the surgical drapes but not in the surgical wound. Suction tips were collected aseptically and placed into thioglycolate broth tubes for qualitative aerobic and anaerobic bacterial culture at the end of each procedure.

Results—Test and control suction tips were contaminated with bacteria during 30 of 44 (68%) procedures. *Staphylococcus* spp were the predominant bacteria in tips used during clean and clean-contaminated surgeries. When surgery was performed on clean-contaminated or contaminated wounds, prevalence of isolation of other bacteria such as *Pseudomonas* spp, *Streptococcus* spp, and *Escherichia coli* from both test and control suction tips was higher than for clean wounds. Mean time of procedures during which both test and control suction tips became contaminated was not significantly different from time of procedures during which neither tip became contaminated.

Conclusion and Clinical Relevance—Surgical suction tips often become contaminated during standard veterinary surgical procedures. The risk of wound infection after surgery may be influenced by bacterial contamination of surgical suction tips. (*Am J Vet Res* 2000;61:779–783)

Wound infection develops in approximately 5% of cats and dogs after surgery.[1,2] Infected surgical wounds can result in increased patient morbidity and high treatment costs,[3] especially if the surgical wound becomes colonized by antibiotic-resistant bacteria such as methicillin-resistant *Staphylococcus aureus*.[4] Consequently, minimizing bacterial contamination of wounds during surgery is an important objective.

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From the Department of Small Animal Medicine and Surgery, The Royal Veterinary College, University of London, Hawkshead Ln, North Mymms, Hertfordshire AL9 7TA, UK. Dr. Muir's present address is the Department of Surgical Sciences, School of Veterinary Medicine, University of Wisconsin, Madison, WI 53706.
Address correspondence to Dr. Muir.

The number and species of bacteria within surgical wounds is influenced by various factors. Clipping hair before induction of anesthesia increases surgical wound infection rates 3-fold as a consequence of bacterial colonization of injured skin.[3] Duration of surgery is also an important risk factor; the risk of infection of clean wounds doubles with every hour of operating time.[3] Tissue injury from manipulation, endocrine disease, immune suppression, and aging also reduce resistance to infection.[5]

Sources of bacteria that contaminate surgical wounds include the patient, the surgeon, surgical equipment, and operating room air.[2,6] Eighty percent of bacteria in surgical wounds are derived from the air in operating rooms.[6] Development of laminar airflow operating rooms has led to significant reduction in the concentration of airborne bacteria, compared with conventionally ventilated operating rooms.[7] Use of occlusive surgical clothing has also been shown to reduce the number of airborne bacteria and incidence of wound infection in human patients.[6,7] The concentration of airborne bacteria in veterinary operating rooms is likely to be high, because they are not usually equipped with laminar airflow. Furthermore, occlusive patient drapes and occlusive clothing are not always routinely used for operating room personnel.

Suction is used routinely in many veterinary surgical procedures. Airborne bacteria adhere to the surgical suction tip as air is continuously drawn into the tube.[8] Duration of use is also thought to increase the degree of bacterial contamination of the suction tip.[9] Because the suction tip has the potential to inoculate the surgical wound with collected airborne bacteria,[10] the purpose of the study reported here was to determine the prevalence of bacterial contamination of surgical suction tips used during a variety of small-animal surgical procedures. We hypothesized that a large proportion of surgical suction tips would become contaminated with bacteria if surgical procedures on dogs and cats were performed in conventionally ventilated operating rooms.

Materials and Methods

Surgical procedures—Data were collected from 44 surgical procedures performed on 42 dogs and 2 cats at the Queen Mother Hospital for Animals at The Royal Veterinary College, University of London. Medical records were examined for clinical diagnosis and preoperative bacterial culture results. Surgical procedures were classified into 3 categories according to the degree of bacterial contamination of the surgical site (clean, clean-contaminated, contaminated).[11]

Procedures were performed in 3 operating rooms that did not have laminar airflow but were maintained at a positive air pressure by conventional ventilation.

Cefuroxime[a] (20 mg/kg of body weight, IV) was given to selected patients for antibiotic prophylaxis 30 minutes before surgery, and repeated doses were given every 2 hours during surgery as necessary. Patients and surgeons were prepared for surgery, using standard surgical protocols to minimize wound contamination.[5] Before entering the operating room, hair at the surgical site was clipped immediately after induction of general anesthesia, and the skin was scrubbed with chlorhexidine[b] soap. After entering the operating room, the surgical site was scrubbed again with fresh chlorhexidine soap and sprayed with 100% ethanol.[c] After the ethanol had evaporated, a povidine iodine[d] solution was used for final preparation of the surgical field. Chlorhexidine[b] or povidine iodine[d] scrub brushes were used for preparation of the surgeon's hands before gloving. Gowns, masks, and surgical caps or hoods were worn for every procedure. Duration of surgery, use of woven cotton or impervious disposable drapes and gowns, and occurrence of any contaminatory events during surgery were recorded. The number of people in the operating room and their movements during surgery were not recorded.

Suction tips—During each procedure, 2 sets of identical suction apparatuses were used for test and control suction tips. Test tips were used normally for suction of blood and fluid during surgery. Control tips were rested on the surgical drapes but were not placed into the surgical wound. The plastic suction tips[e] were connected to separate suction pumps[f-h] with sterile tubing.[i] Air flow through the suction pump was in the range of 28 to 30 L/min. Continuous or intermittent suction was used, and suction was switched on or off by the operating room personnel, as required by the surgeon. The control suction line was switched on and off at the same time as the test suction line. At the completion of each procedure, new sterile gloves were used to handle the suction tips. Two-centimeter lengths of the test and control suction tips were cut, using sterile scissors from a separate surgical pack, and the tips were placed into separate tubes containing thioglycolate broth for qualitative bacterial culture.

To examine the effect of movement of the patient and operating room personnel on bacterial contamination of suction tips, suction tips were also submitted for bacterial culture after they had been placed in an operating room devoid of patients or personnel. Suction tips were set up in triplicate in an operating room that had not been in use for the preceding 24 hours. Suction was operated continuously for 0.5, 1, 1.5, 2, or 4 hours. At the end of each interval, the 3 suction tips were collected for qualitative bacterial culture.

Bacterial culture—Procedures for culture and identification of bacteria were performed according to a described protocol for investigation of contamination of suction tips.[9] Suction tips were incubated in thioglycolate broth at 37 C for 2 days, and a loopful of broth was then subcultured onto MacConkey and blood agar plates. MacConkey and blood agar plates were incubated under aerobic conditions at 37 C for 2 days. Separate blood agar plates were also incubated under anaerobic conditions at 37 C for 2 days. Plates were examined for bacterial growth, and 2 colonies of each morphologic type were first stained with Gram's stain and tested for catalase activity. A modified oxidase reaction was also used to differentiate between staphylococci and micrococci.[12] Isolates were further identified by type of growth on blood agar and MacConkey plates, whether or not the isolate would grow under aerobic or anaerobic conditions, evaluation of hemolysis on blood agar plates, and results of DNAse and coagulase tests. Coagulase- and DNAse-positive staphylococcal isolates were identified as *Staphylococcus aureus* or *Staphylococcus intermedius* by use of a commercially available identification system.[j] When necessary, gram-negative isolates were further identified, using another identification system.[k]

Statistical analyses—Animals were grouped on the basis of bacterial status of the suction tip (positive or negative) and sex (male and female), and ANCOVA was used to test for differences among groups in regard to operating time. Body weight and age were included as covariates. When a major comparison was not significant, the **percentage of difference (Δ)** between populations that yielded a power of 0.8 was calculated.[13]

A multiple logistic regression model was used to identify factors independently associated with the bacterial status (contaminated or not contaminated) of the test and control suction tips during surgery. The factors evaluated for inclusion in the model were age, body weight, sex, operating time (> or < 2 hours), wound category (clean, clean-contaminated, contaminated), perioperative antibiotic status (antibiotic given or not given), and draping and gowning (use of impervious or cloth gowns and drapes). Analyses were performed with statistical software.[l,m] Values of $P < 0.05$ were considered significant.

Results

A number of different surgical procedures were performed on a variety of organs and structures (**Table 1**). No contaminatory events were identified during any procedure. Mean (± SD) operating time was 2.4 ± 0.8 hours. The briefest operating time for which bacterial contamination of a suction tip was detected was 1 hour; both test and control tips were contaminated during this procedure. Mean time of procedures during which both test and control suction tips became contaminated was not significantly different from time of procedures during which neither tip became contaminated. Operating time was not significantly

Table 1—Types of surgical procedures performed on 42 dogs and 2 cats with use of surgical suction

Classification*	Surgical procedure (No.)
Clean	Arthrotomy (5)
	Hemilaminectomy (4)
	Tibial crest transposition/sulcoplasty (3)
	Pelvic fracture repair (2)
	Total hip replacement (2)
	Ventral slot (2)
	Femoral head and neck excision (1)
	Pericardectomy (1)
	Splenectomy (1)
	Stabilize luxated elbow joint (1)
	Prosthetic capsular repair for luxated hip joint (1)
	Triple pelvic osteotomy (1)
Clean-contaminated	Ureteroneocystostomy (2)
	Colposuspension (1)
	Cystotomy (1)
	Laparotomy and intestinal biopsy (1)
	Gastrectomy (1)
	Nephrectomy/gastrotomy (1)
	Ovariohysterectomy (1)
	Thoracotomy for chylothorax (1)
	Thoracotomy and esophagotomy (1)
Contaminated	Total ear canal ablation (8)
	Premaxillectomy (1)
	Rostral mandibulectomy (1)

*Classification system described by the National Research Council, Division of Medical Sciences.[11]

Table 2—Number of test and control surgical suction tips* from which various bacteria were isolated following clean, clean-contaminated, and contaminated small-animal surgical procedures

	Procedure classification†					
	Clean		Clean-contaminated		Contaminated	
Bacteria isolated	Test (n = 24)	Control (n = 24)	Test (n = 10)	Control (n = 10)	Test (n = 10)	Control (n = 10)
None	2	9	2	1	0	0
Staphylococcus spp (coagulase negative)	19	15	4	7	3	8
Staphylococcus spp (coagulase positive)	1	0	0	0	2	0
Streptococcus spp	2	0	1	1	4	3
Pseudomonas spp	0	1	2	0	5	3
Clostridium spp	0	0	1	0	0	0
Escherichia coli	1	0	2	1	2	0
Agrobacterium spp	2	0	1	0	0	0
Citrobacter spp	1	0	0	0	0	0
Micrococcus spp	1	0	0	0	0	0
Bacillus spp	0	1	1	0	0	0
Corynebacterium spp	0	1	0	0	0	0

*Test tips were used normally for suction of blood and fluid during surgery. Control tips were rested on the surgical drapes but were not placed into the surgical wound. †Classification system described by the National Research Council, Division of Medical Sciences.[11]

Table 3—Types of bacteria isolated from test and control suction tips* following surgery on 12 dogs and 1 cat for which presurgical bacterial culture results were available

	Bacteria isolated		
Procedure†	Before surgery	Test tip	Control tip
Clean-contaminated			
Cystotomy	None	*Agrobacterium* spp	None
Ureteroneocystostomy	*Staphylococcus* spp *E coli*	*E coli*	*Staphylococcus* sp
Thoracotomy	*Pseudomonas* spp	*Staphylococcus* spp	*Staphylococcus* spp
Nephrectomy/gastrotomy	None	*Staphylococcus* spp	*Streptococcus* spp
Ureteroneocystostomy	None	None	*Staphylococcus* spp
Contaminated			
TECA	*Pseudomonas* spp	*Pseudomonas* spp	*Staphylococcus* spp
TECA	*Proteus* spp *Enterococcus* spp	*Pseudomonas* spp *Staphylococcus* spp	*Staphylococcus* spp *Streptococcus* spp
TECA	*Pseudomonas* spp	*Pseudomonas* spp	*Pseudomonas* spp
TECA	*Pseudomonas* spp *S intermedius*	*Pseudomonas* spp *Streptococcus* spp	*Staphylococcus* spp *Streptococcus* spp
TECA	*Pseudomonas* spp *E coli*	*E coli*	*Staphylococcus* spp
TECA	*S intermedius*	*S intermedius*	*S intermedius*
TECA	*S intermedius*	*Pseudomonas* spp *Streptococcus* spp	*Pseudomonas* spp *Staphylococcus* spp
TECA	*Pseudomonas* spp	*E coli*	*Staphylococcus* spp

All *Staphylococcus* spp isolated were coagulase negative.
E coli = *Escherichia coli*. TECA = Total ear canal ablation. *S intermedius* = *Staphylococcus intermedius*.
See Table 2 for key.

(power = 0.8; Δ = 13%) influenced by patient age, sex, or weight. None of the parameters examined in the multiple logistic regression model were significantly related to bacterial contamination of the test and control suction tips.

Perioperative antibiotics were given during 43 (98%) procedures (24 clean, 9 clean-contaminated, 10 contaminated). Perioperative antibiotics were not given during 1 clean-contaminated procedure. Impervious gowns and drapes were used in 27 of 44 (61%) procedures.

Bacteria were cultured from either the test or control suction tip or both tips after all procedures. Bacteria were cultured from both tips after 30 (68%) procedures, from only test tips after 10 (23%) procedures, and from only control tips after 4 (9%) procedures. Different species of bacteria were isolated from the test and control tips after 15 of 30 (50%) procedures in which both suction tips were contaminated. Of the procedures in which different species of bacteria were isolated from test and control tips, 2 were clean, 5 were clean-contaminated, and 8 were contaminated. When surgery was performed on clean-contaminated or contaminated wounds, prevalence of isolation of *Pseudomonas* spp, *Streptococcus* spp, and *Escherichia coli* from both test and control suction tips was higher, compared with prevalence of isolation after surgery on clean wounds (**Table 2**). Coagulase-positive

staphylococci were isolated from 3 test suction tips and 1 control suction tip. These isolates were typed as *Staphylococcus intermedius* (n = 3) and *Staphylococcus aureus* (1). The test suction tip was contaminated with bacteria in 32 of 36 (89%) procedures that lasted > 2 hours and in 8 of 8 procedures that lasted < 2 hours. The control suction tip was contaminated with bacteria in 28 of 36 (78%) procedures that lasted > 2 hours and in 6 of 8 (75%) procedures that lasted < 2 hours.

Preoperative bacterial culture results were available for 13 of 44 (30%) animals. When gram-negative bacteria were isolated from a body region before surgery, similar genera of bacteria were isolated from the test suction tip after 5 of 13 procedures, whereas similar genera of bacteria were isolated from the control suction tip after only 1 of 13 procedures **(Table 3)**. The only bacteria isolated from suction tips in the absence of operating room personnel or a patient were *Staphylococcus* spp. Six of 15 (40%) suction tips were contaminated with bacteria, and contaminated tips were identified as early as 30 minutes after initiation of suction.

Discussion

We have shown that surgical suction tips may commonly become contaminated with bacteria during veterinary surgical procedures, including those of brief duration. Many of the bacteria isolated from contaminated suction tips appeared to have been derived from operating room air. Contamination of surgical suction tips with bacteria in room air may pose an important risk to development of wound infection after surgical procedures. However, once the tip becomes contaminated, it is unclear how easily bacteria can move from the suction tip into the wound, particularly when a vacuum is being applied to the suction line.

The most common types of bacteria isolated from suction tips were *Staphylococcus* spp, including, at times, pathogenic strains. It has recently been shown that surgical wounds in dogs can become infected with methicillin-resistant *Staphylococcus aureus*, a human pathogen.[4] The surgical suction tip is one possible route that such bacteria may be transmitted from human beings to the wound of an animal patient.

Bacteria were isolated from 22 of 24 (92%) test suction tips used for clean procedures, as opposed to only 11 of 30 (37%) tips collected from clean orthopedic procedures performed on human beings in operating rooms with conventional ventilation.[9] Reasons for the higher tip contamination rate associated with veterinary patients in our study may include treatment of patients with dense coats and variations in the number and movement of operating room personnel. Clipping the hair before induction of anesthesia may reduce the amount of loose hair and airborne bacteria. However, the risk of wound infection after surgery is increased, because bacteria colonize small clipper-induced lacerations.[3]

Although number and movements of operating room personnel were not recorded in this study, there is evidence from other studies that movement of personnel is a more important cause of bacterial shedding into operating room air than the type or duration of the surgical procedure.[14] Quantitative analysis indicated that there was a 12-fold increase in mean total bacterial counts from an in-use operating room, compared with counts from an empty operating room.[15] Use of cotton gowns and drapes versus impervious disposable gowns and drapes can also influence dispersal of bacteria. Use of impervious disposable surgical gowns reduces the dispersal rate of bacterial particles by 30% in conventionally ventilated operating rooms and 65% in operating rooms with laminar airflow.[16] Loss of barrier function by strikethough of fluid, originating from either the surgeon or external to the gown, occurs in 90% of cotton gowns, compared with only 3% of impervious disposable gowns.[17] This greater rate of strikethrough may also potentiate transmission of bacteria into surgical wounds by routes other than air. There was no evidence that suction tip contamination in our study was influenced by clinical variables such as draping and gowning, wound category, and use of perioperative antibiotics.

Different bacteria were isolated from test and control suction tips in half of the procedures in which bacteria were isolated from both tips. Bacteria isolated from control tips appeared principally to have been derived from operating room air and were mainly nonpathogenic staphylococci, as has been described for medical operating rooms.[14,15] Therefore, it seems likely that pathogenic bacteria such as *E coli* and *Pseudomonas* spp isolated from control tips contaminated the tips after these bacteria were released into operating room air during movement of the patient or personnel or by dispersal of bacteria during surgery on a contaminated wound.

If bacterial contamination of suction tips is found to be an important risk factor for wound infection, alterations in operative protocols that reduce contamination during veterinary surgeries may be important. Such alterations include use of laminar airflow ventilation, disposable nonwoven operating gowns, and intermittent suction, changing the suction tip during the course of prolonged surgical procedures,[10] and limiting movement of personnel. It would be helpful to quantitate the number of bacteria in suction tips after procedures of different duration and determine how easily bacteria may move from the tip into the wound while suction is applied. Tips became contaminated with bacteria quickly in our study, but tip contamination did not have a significant relationship with operating time. However, the number of bacteria within the tip may increase with increasing operating time. Our experimental protocol was designed to minimize the risk of false-negative results, and many tips may have contained only a few bacteria.

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[a]Zinacef, Glaxo, Uxbridge, UK.
[b]Hibiscrub, Zeneca, Macclesfield, UK.
[c]Labpak, Fillongley, Coventry, UK.
[d]Vetasept, Animal Care, York, UK.
[e]Yankauer, Vygon, Paris, France.
[f]SAM 14 Medical Suction, MG Electric, Colchester, UK.
[g]Vacumaster 9701, Seward, Sur-med Supplies Ltd, New Barnet, UK.
[h]Suction Apparatus, Allen & Hanburys Ltd, London, UK.
[i]Connecting tube, Portex, Hythe, UK.
[j]API ID32 STAPH, Bio-Mérieux UK, Basingstoke, UK.

[k]API 20 NE, Bio-Mérieux UK, Basingstoke, UK.
[l]Systat, version 6.0, SPSS Inc, Chicago, Ill.
[m]SPSS, version 6.1, SPSS Inc, Chicago, Ill.

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