Major Article

Perioperative hair removal in the 21st century: Utilizing an innovative vacuum-assisted technology to safely expedite hair removal before surgery

Charles E. Edmiston Jr PhD [a,*], Russell K. Griggs MS [b], Judith Tanner PhD [c], Maureen Spencer MEd, RN [d], Gary R. Seabrook MD [a], David Leaper DSc [e]

[a] Department of Surgery, Medical College of Wisconsin, Milwaukee, WI
[b] BioScience Laboratories, Inc, Bozeman, MT
[c] School of Health Sciences, University of Nottingham, Nottingham, United Kingdom
[d] Infection Prevention Consultants, Boston, MA
[e] Institute of Skin Integrity and Infection Prevention, University of Huddersfield, Huddersfield, United Kingdom

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Background: Perioperative hair removal using clippers requires lengthy cleanup to remove loose hairs contaminating the operative field. We compared the amount of hair debris and associated microbiologic contamination produced during clipping of surgical sites using standard surgical clippers (SSC) or clippers fitted with a vacuum-assisted hair collection device (SCVAD).
Methods: Trained nurses conducted bilateral hair clipping of the chest and groin of 18 male subjects using SSC or SCVAD. Before and during clipping, measurements of particulate matter and bacterial contamination were evaluated on settling plates placed next to each subject's chest and groin. Skin condition after clipping and total clipping/cleanup times were compared between SSC and SCVAD.
Results: The microbial burden recovered from residual hair during cleanup in the SSC group was 3.9 $\log_{10}$ CFU and 4.6 $\log_{10}$ CFU from respective, chest, and groin areas. Use of the SCVAD resulted in a significant ($P < .001$) reduction in both residual hair and microbial contamination within the operative field compared with SSC.
Conclusions: Use of SCVAD resulted in significant ($P < .001$) reduction in total time required to clip and clean up residual hair contaminating the operative field compared with standard practice (ie, SSC), eliminating the need to physically remove dispersed hairs, which can harbor a significant microbial burden, from within the operative field.

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Preoperative hair removal by clipping rather than shaving was among the Surgical Care Improvement Project's sentinel core measures.[1] In an era of value-based purchasing, optimizing the practice of these evidence-based process measures has important financial implications for hospitals and other acute-care facilities.[2,3] Following Association of periOperative Registered Nurses-recommended practices, if a patient's hair is likely to interfere with the surgical procedure and removal is deemed warranted, the following practice is applied:[4]

- Hair removal should be performed on the day of the surgery, in a location outside the operating or procedure room;
- Only hair interfering with the surgical procedure should be removed; and
- Hair should be clipped with a single-use electric or battery-operated clipper, or clipped with a reusable head that can be disinfected between patients.

The location of perioperative hair removal has been a concern of operating room nurses and other health care professionals because hair can be a significant source of microbial contamination and the removal of residual hair is often a time-consuming practice, increasing costly operating room time.[5] Furthermore, on selective

surgical services, such as cardiac, gynecology, and urology, surgeons prefer to clip in the operating room after the patient has been sedated. This conforms to patient privacy concerns and the sensitivity of the area being clipped.

The purpose of this study was to quantify and compare the amount of loose hair or debris, and associated microbiologic contamination, produced during the clipping of surgical sites using standard surgical clippers (SSC) alone or surgical clippers fitted with a vacuum-assisted hair collection device (SCVAD). This study also evaluated total clipping time, abrasion/irritation of the skin during clipping procedures, and clinician and subject satisfaction with the clipping and hair-removal process. The standard practice of using surgical tape to remove residual hair following clipping was also evaluated for its microbial bioburden because loose hair poses a risk for microbial contamination of the surgical field or operating room environment.

MATERIALS AND METHODS

The protocol was reviewed and approved by the Gallatin Institutional Review Board.

Preliminary analysis

An initial pilot study was conducted to assess the feasibility of measuring the level of dispersed microbial and residual hair contamination produced during the clipping process using clippers with or without vacuum collection technology. Following informed consent, 3 subjects had hair clipped from the groin and lower leg regions with or without vacuum-assisted hair collection (ClipVac Hair Vacuum or Surgical Clipper; CareFusion Corp, San Diego, CA). On the left or right groin sites, a sterile surgical marker was used to demarcate a 12-inch × 8-inch bilateral area with a similar amount of hair. Tryptic soy agar (TSA) settling plates were placed adjacent to the test site before clipping. The TSA plates were placed in a 2 plate × 4 plate formation (ie, 8 plates) such that the open plates were positioned beneath the clipping site at 3.25 inches, 6.50 inches, 9.75 inches, and 13.00 inches perpendicular to the test site. The plates were exposed for 3 minutes (negative control), removed, and incubated at 30°C for 48 hours. A second set of plates were placed in the exact same position as the first set. The skin surface was carefully clipped until it was visually apparent that all hair had been removed from the test sites using either SSC or SCVAD. The plates were removed, incubated at 30°C for 48 hours, and microbial colonies from both negative control and experimental runs enumerated. A visual inspection of the groin skin surfaces adjacent to the clipping site revealed no residual hair particles following removal with the SCVAD.

On the skin of the lower leg, a surgical marker was used to demarcate the front plane of the lower leg with areas of skin that appeared bilaterally similar in terms of the amount of hair. A preweighed piece of paper was place beneath each leg. The hair was carefully clipped until it was visually apparent that hair was entirely removed from the test site by either the SSC or SCVAD. The preweighed pieces of paper were removed from beneath the volunteer's leg and reweighed. A visual inspection of the lower leg skin surfaces adjacent to the clipping site revealed no residual hair particles following removal with SCVAD.

Simulated surgical clipping study

Following informed consent and before randomization, the skin of the study subjects were examined to assess that it was free from clinically evident diseases, injuries, or any other disorders that could compromised the study.

Inclusion/exclusion criteria

Subjects were included in this study if they met the following requirements:

- Male, aged at least 18 years, including any ethnic background,
- Moderate to heavy (≥ 3 on Ferriman-Gallwey scale for hirsutism) hair on chest and groin,[6]
- Available to take a shower or bathe approximately 24 hours before testing, and
- In good general health.

Subjects were excluded if they had any of the following criteria:

- Presence of tattoos, insufficient hair, scars, erythema, sunburn, skin diseases, moles, cuts, lesions, skin tags, protruding veins, or other disorders on the skin of the chest or groin that might have interfered with consistent use of the test materials across a test site or with the evaluation of responses to test material use;
- Known allergy or sensitivity to sunscreens, deodorants, laundry detergents, fragrances, latex (rubber), metals, adhesives, or ink;
- Exposure of test sites to strong detergents, solvents, or other irritants within a 7-day pretest conditioning period or on the single test day;
- Exposure of test sites to antimicrobial agents, medicated soaps, medicated shampoos, or medicated lotions, use of biocide-treated pools or hot tubs, use of tanning beds, or sunbathing during the 7-day pretest conditioning period or on the single test day;
- Use of systemic or topical antibiotic medications, steroid medications, or any other products known to affect the normal microbial flora of the skin during the 7-day pretest conditioning period or the single test day;
- Removal of hair from any portion of the test sites within the prior 30 days; and
- Any currently active skin disease or inflammatory skin condition, such as contact dermatitis, eczema, or psoriasis, anywhere on the body or use of any medications that, in the opinion of the principal investigator or medical consultants, should preclude participation.

A total of 24 men consented to participate in the study; 5 subjects were excluded during preliminary examination, 19 received study materials, and 18 subjects completed the study without any protocol violations.

Pretesting period

Seven days before the study, subjects were instructed to avoid use of medicated soaps, lotions, deodorants, and shampoos, as well as skin contact with solvents, detergents, acids and bases, or any other products known to affect the normal microbial populations of the skin. Subjects were provided with a personal hygiene kit containing nonmedicated soap, shampoo, lotion, and rubber gloves to be worn when in contact with antimicrobial agents, solvents, detergents, acids, or bases that could not be avoided. Subjects were instructed to exclusively use the contents of the kit during their participation in the study. The study subjects were instructed not to shave or clip the test sites during the 7 days before their assigned test day. Subjects were instructed to avoid swimming or bathing in biocide-treated pools or hot tubs. Subjects were also told that they must shower or bathe approximately 24 hours before testing.

Table 1
Test assignments for subjects undergoing clipping of chest and groin

Site	Performance differentiator evaluated	Standard surgical clipper	Surgical clippers with vacuum-assisted hair collection device
Chest and groin	Time to clip and removal and hair particulate collected	Hair clipped with standard surgical clipper and removed with tape	Hair clipped with surgical clippers with vacuum-assisted hair collection device
		Particulate matter on tape used for hair cleanup weighed	
	Hair particulate dispersion and associated microbial contamination	Settling plates collected before and during clipping	
		Airborne particulate matter measured with airborne particle counter instrument before and during clipping	
	Irritation/microabrasion of surgical site*	Mexameter (erythema) and tewameter (transepidermal water loss) readings and visual evaluation of erythema/dryness before clipping, following clipping, and following postclipping hair removal	
	Subject–clinician satisfaction	Subject–clinician questionnaire	
	Bioburden evaluation on surgical tape	Tape was sampled following use for microbial contamination	Not applicable

*Chest-specific.

Study period

A computer-generated randomization method was used to randomly assign which matched sites (chest and groin) were to be clipped using SCVAD compared with SSC. Table 1 documents the test procedure assignments for both the chest and groin test sites. Test sites were visually inspected by a trained technician and nurse. The height and weight of each subject was used to determine body mass index. The matched right or left chest sites tested included the anterior aspect of the chest between the umbilicus and the clavicle on each side of the midline. The matched inguinal test sites included the medial aspect of the right or left thigh. A sterile surgical marker was used on the inguinal test sites, standardizing a 12-inch × 8-inch templated area for clipping.

Baseline measurements of potential microbial contamination were evaluated using settling TSA Petri dishes placed next to each subject's chest (4 plates) and groin (6 plates) with the tops removed and exposed for 10 ± 1 minutes. Simultaneously, baseline measurements of airborne particulate matter were evaluated via an airborne particle counter instrument (DustTrak DRX Aerosol Monitor 8534; TSI Incorporated, Shoreview, MN) that was hung from a portable intravenous line pole placed as close to the site of clipping as possible. An assessment of skin condition was made before any clipping of the chest using a mexameter (Courage & Khazaka Electronic GmbH, Cologne, Germany) to measure skin erythema and a tewameter (Courage & Khazaka Electronic) to measure transepidermal water loss (TEWL), together with visual evaluation of erythema and dryness. No assessment of skin condition of the groin was conducted. The location of each measurement was marked using a sterile surgical marker to ensure that later measurements were taken from the same location.

Following baseline measurements, 3 trained nurses clipped subjects bilaterally using the randomly assigned clippers (SSC or SCVAD), beginning with the chest and then groin. New TSA settling plates were placed next to the test sites in the same earlier configuration to capture airborne hair particles during the clipping process. The microbial contamination was quantified for comparison to baseline. These plates were left open for the duration of clipping. Following clipping, the TSA plates were gently shaken to distribute any loose hair across the surface of the plate. Measurement of airborne particulate matter was evaluated during clipping using the airborne-particle counter instrument. Airborne particulate sampling began at approximately the same time as opening of the settling plates and ended once clipping was completed.

The length of time required for each clipping procedure, using either the SSC or SCVAD devices, was measured. Airborne particulate matter was sampled immediately after clipping using the airborne particle counter for a period of 3 minutes. In addition, skin surface readings using the mexameter and tewameter and visual evaluation of erythema or dryness were conducted immediately after each chest clipping. Erythema measurements and TEWL were assessed solely on chest sites due to the difficulty of conducting these studies in the groin. Any excess clipped hair contaminating the operative field was removed by a nurse using a 12-inch section of surgical tape while wearing sterile gloves. Microbial bioburden evaluation was performed on the surgical tape to determine the level of microbial contamination present. Five 12-inch portions of unused surgical tape were each placed aseptically into separate sterile stomacher bags for use in determining the background bioburden present on tape before contact with each subjects' skin. Each used portion of surgical tape was also placed into a separate sterile stomacher bag following use. Twenty milliliters stripping suspending fluid was poured into each bag and the bag massaged in a uniform manner for 60 seconds using a Seward 400 Stomacher machine (Cole-Parmer, Vernon Hills, IL). Following massage, a 5-mL aliquot was removed from each bag and placed into a sterile test tube and serially diluted for quantitative plate counts. Duplicate spread plates (using TSA) were prepared from appropriate dilutions using Butterfield's Phosphate Buffer solution. Colony counts were determined following incubation for 72 hours at 30°C.

The nurses who performed the clipping and study subjects were queried following hair removal regarding their opinions on efficacy and comfort associated with use of the SSC or SCVAD.

Analytical and statistical analysis

The estimated Log_{10} number of viable microorganisms recovered from surgical tape bioburden samples from each sample site was designated the R value. To convert the recorded colony counts from each sample into the Log_{10} colony forming units, the following formula was employed:

$$R = Log_{10}[20 \times Ci \times 10^{-D}]$$

Where 20 = the amount (in milliliters) of stripping suspending fluid used in sampling, Ci = the arithmetic average colony count of the 2 plate counts from each sample at a particular dilution level, and D = the dilution factor. An analysis of variance (ANOVA) was conducted for each test site (chest or groin) using the following factors, as applicable. This ANOVA was of the form:

$$\hat{y} = Blocks + A + e$$

Where $\hat{y}$ = 1 of 7 factors:

1. Combined duration of clipping and hair collection—groin,
2. Combined duration of clipping and hair collection—chest,

3. Amount of hair (collected via settling plates)—groin,
4. Amount of hair (collected via settling plates)—chest,
5. Microbial contamination from clipping—groin,
6. Microbial contamination from clipping—chest, and
7. Erythema or TEWL (chest),

A = test agent; that is, SSC or SCAD, and e = error (factor).

RESULTS

In the preliminary pilot analysis, the mean dispersed microbial recovery (Log$_{10}$ colony-forming units) associated with inguinal hair removal from test subjects using the SSC or SCVAD is reported in Table 2. In addition, the mean weight of recovered hair from beneath the test site on the volunteer's lower leg clipped with SSC was 0.212 g, whereas the mean weight of hair recovered from beneath the test site clipped with SCVAD was 0.003 g. These preliminary findings suggest that compared with SSC, the SCVAD was highly effective in reducing the dispersion of contaminated hair fibers within the areas adjacent to the skin-prepping site.

The findings from the operating room-simulated study document that the use of SSC required a significantly (ANOVA, $P < .001$) longer time for clipping and cleanup/removal (combined duration) of hair from chest test sites compared with use of SCVAD. When SSC were used, it took more than 5.3 minutes for clipping and cleanup/removal of hair from chest sites, whereas use of SCVAD required approximately 3.2 minutes. In the groin, use of a SSC required a significantly (ANOVA, $P < .001$) longer time for clipping and hair cleanup/removal (combined duration) compared with use of the SCVAD. It took approximately 4.2 minutes (maximum, 8.5 minutes) for clipping and cleanup/removal of hair from groin test sites when SSC were used, whereas use of the SCVAD required approximately 2.7 minutes (maximum, 4.9 minutes).

The use of SSC without vacuum-assisted hair removal (and subsequent hair removal with surgical tape) resulted in significantly (ANOVA, $P < .001$) more loose hairs (on a Log$_{10}$ scale) dispersed from chest test sites than following use of the SCVAD. The use of SSC (and subsequent hair removal with surgical tape) resulted in significantly (ANOVA, $P < .001$) more loose hairs (on a Log$_{10}$ scale) dispersed from groin test sites compared with SCVAD. The mean particulate hair contamination (and 95% confidence intervals) from chest and groin test sites following use of SSC or SCVAD are documented in Figure 1.

The use of the SSC (and subsequent hair removal with surgical tape) resulted in significantly (ANOVA, $P < .001$) more microbial contamination from chest test sites than following use of the SCVAD. The use of the SSC without the vacuum-assisted hair removal (and subsequent hair removal with surgical tape) produced significantly (ANOVA, $P < .003$) more microbial contamination from groin

Table 2
Pilot summary of mean Log$_{10}$ (colony forming units) microbial recovery (difference) between pre- and postclipping agar plates from inguinal sites clipped with standard surgical clipper (SSC) versus surgical clipper fitted with vacuum-assisted device (SCVAD)

Samples	Sample size SSC/SCVAD	Mean SSC/SCVAD	Standard deviation SSC/SCVAD	Minimum SSC/SCVAD	Maximum SSC/SCVAD
Agar plates 3.25 in from inguinal site	6/6	1.87/0.23	0.69/0.36	1.05/0.00	2.68/0.70
Agar plates 6.50 in from inguinal site	6/6	0.55/0.13	0.46/0.37	−0.18/−0.48	1.08/0.48
Agar plates 9.75 in from inguinal site	6/6	0.09/0.02	0.27/0.34	−0.30/−0.48	0.48/0.60
Agar plates 13.00 in from inguinal site	6/6	0.18/0.03	0.27/0.25	0.00/−0.30	0.70/0.48
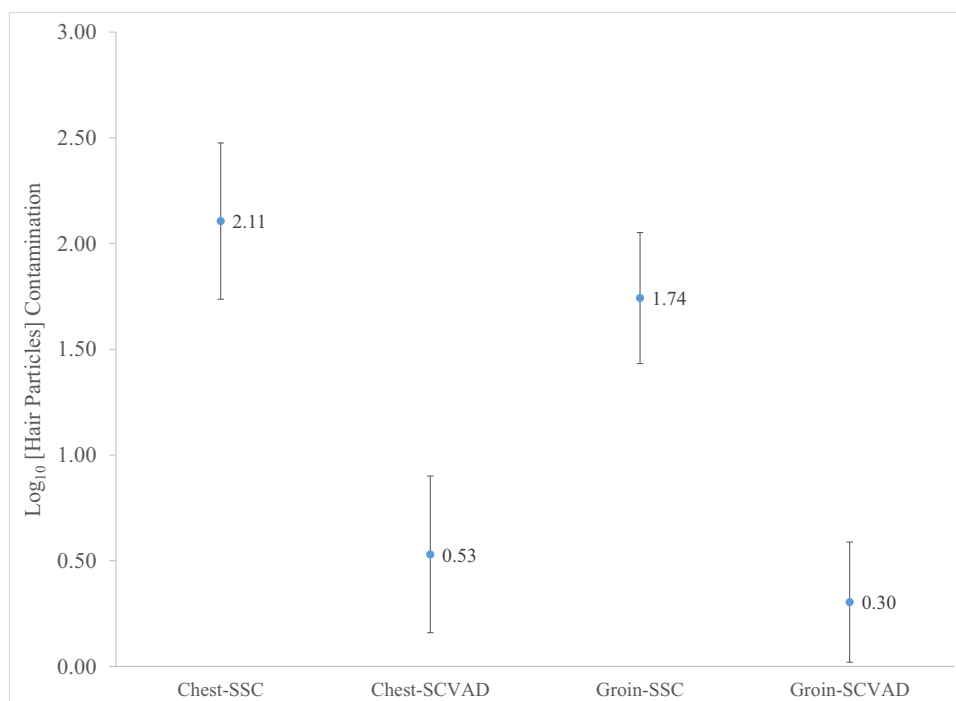
Fig 1. Volume (Log$_{10}$) of hair (and 95% confidence intervals) collected via settling plates using standard surgical clipper (SSC) (control) or surgical clippers with vacuum-assisted hair collection device (SCVAD) on chest and groin ($P < .001$).
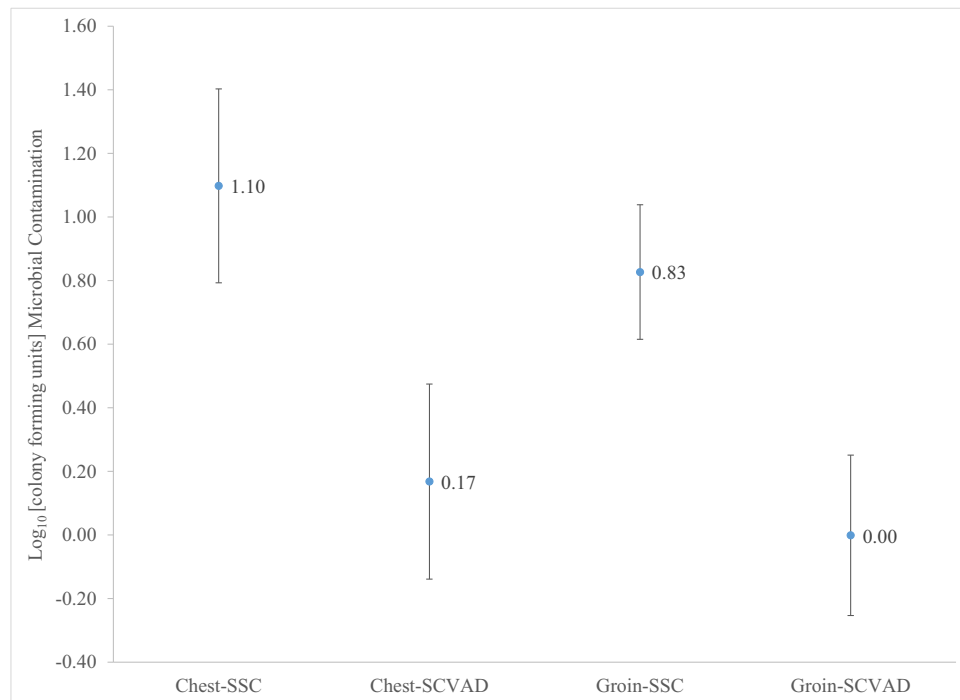
Fig 2. Mean microbial contamination following hair removal using standard surgical clippers (SSC) (control) or surgical clippers with vacuum-assisted hair collection device (SCVAD) on chest and groin ($P < .001$).

test sites than following use of the SCVAD. The mean microbial contamination (and 95% confidence intervals) from comparative chest sites and groin sites following use of SSC or SCVAD are documented in Figure 2. The mean microbial contamination recovered from surgical tape following clipping with SSC in the chest and groin was in excess of 3.5 Log_{10} cfu, with a maximal microbial recovery of 5.4 and 6.2 Log_{10} cfu from chest and groin sites, respectively.

The use of the SSC or SCVAD produced equivalent (ANOVA, $P = .124$) skin changes from baseline erythema measurements for chest test sites following tape removal of residual hair clippings. The use of the SCC (and subsequent hair removal with surgical tape) produced a significantly ($P < .001$) higher measured change in TEWL at chest test sites compared with use of the SCVAD; that is, 1.12 g/h/ m^2 and –0.55 g/h/m^2, respectively. Following study completion, study nurses responded that the benefits of using the SCVAD included an increase in speed of clipping and a significant increase in cleanliness following the clipping process, whereas study subjects indicated that they experienced little to no discomfort during the clipping process.

DISCUSSION AND PRACTICAL IMPLICATIONS

Despite efforts to institute national initiatives and guidelines to reduce the risk of health care-associated infections, selective infections such as postoperative wound infections persist as a source of significant patient morbidity and mortality.[7] Preparation for surgery has historically involved the routine removal of body hair at and around the operative site. The rationale for hair removal has been centered around the concern that body hair may interfere with visualization of the surgical wound, closure of the surgical incision, diminished adherence of incised drapes to the skin, or possibly a reduction in the effectiveness of skin antisepsis at the incision site due to bacterial contamination. Evidence-based practice suggests that hair removal using an exposed blade or razor may increase the risk of wound contamination due to the presence of microscopic

nicks or scratches that occur during the shaving process.[8-12] These microscopic injuries are rapidly colonized, increasing the microbial skin burden leading to an increased risk of wound infection.[11] The 1999 Centers for Disease Control and Prevention Guidelines for the Prevention of Surgical Site Infections indicate that, "If hair is to be removed, remove immediately before the operation, preferably with electric clippers" (Category 1A evidence-based).[13]

Both the Centers for Disease Control and Prevention and Association of periOperative Registered Nurses recommendations state that hair removal should be conducted outside the operating room. Although there has never been an evidence-based analysis of whether clipping (hair removal) within an operating room represents a specific health care-associated infection risk factor, it often represents a focus of discussion among members of the operative team. Time and space constraints along with concerns for patient privacy often dictate that hair removal should occur within the operating room and that the entire process from clipping to cleanup can occupy several minutes of dedicated operating room time. In addition, the clipping process with a battery-operated clipper, depending upon the amount of body hair, can disperse hair particles over a wide area, depositing hair several inches from the clipped surgical site (Table 2). The results of this study suggest that the attachment of an SCVAD to the head of the surgical clipper is effective in removing hair at the point of clipping. The hair is drawn up into the hood of the SCVAD and collected in an end-stage filter. The filter cassette is capable of collecting a large volume of hair, preventing hair particle dispersion within the surgical field or operating room environment (Fig 3). The vacuum is achieved by a lithium-ion powered pump weighing approximately 1.6 lb. The system is highly portable and can be moved easily from room to room as needed.

The results of this study document that clipped hair particles are associated with notable microbial contamination. The use of a battery-operated surgical clipper with innovative vacuum-assisted technology for collection of surface hair before surgery is effective ($P < .001$) in the rapid removal and collection of hair particles that

Fig 3. Picture of opened collection filter cassette, demonstrating large volume of clipped hair captured during clipping process using surgical clippers fitted with vacuum-assisted hair collection device (SCVAD).

may pose a risk for contamination of the operative site. The investigation documented that postclipping cleanup of the patient's skin and surrounding adjacent surface areas can be eliminated by using a clipper with vacuum-assisted technology, sequestering clipped hair particles within a closed container, resulting in substantial time savings before perioperative skin antisepsis and draping. The investigation also demonstrated a mean increase in TEWL following hair clipping with SSC and cleanup of residual hair particles using surgical tape. An increase in TWEL suggests that following repeat applications of surgical tape to skin test sites, structural changes occurred that affected the moisture balance in the outermost portion of the stratum corneum. TEWL is by convention used as a marker for skin barrier function that in the present study was altered during postclipping cleanup. The removal of residual hair with adhesive tape often required multiple passes to ensure complete removal of clipped hair from the surgical field before skin antisepsis. When the tape was sampled for microbial burden, a mean colony count of 3.9 Log_{10} CFU and 4.6 Log_{10} CFU was recovered from the chest and groin, respectively, suggesting that clipped hair can be a significant source of bacterial contamination within the surgical field.

Previous studies in our laboratory have documented that a wide range of microbial populations, including *Staphylococcus aureus*, *Staphylococcus epidermidis,* and selective gram-negative bacteria are present within 1-2 m of the incision site, posing a potential risk of infection, particularly when procedures involve insertion of a biomedical device or prosthesis.[14] The findings of the current study document that using a battery-operated surgical clipper fitted with vacuum-assisted hair collection technology was effective in the complete removal of clipped hair particles from the operative field. Finally, in addition to eliminating the time required to clean up residual hair particles, the vacuum-assisted collection system was effective at reducing the potential microbial burden associated with clipped loose hair as a potential source of operative field contamination. Further research is warranted to evaluate the potential benefits of this innovative perioperative hair removal/collection technology.

References

1. Jones RS, Brown C, Opelka F. Surgeon's compensation, "Pay for Performance": the American College of Surgeons National Quality Improvement Program, the Surgical Care Improvement Program and other programs. Surgery 2005;138:829-36.
2. Centers for Medicare and Medicaid Services. Medicare program: hospital inpatient value-based purchasing program. Fed Regist 2011;76:2454-91.
3. Centers for Medicare and Medicaid Services. FY 2014 achievement performance standards for clinical process of care measures. Fed Regist 2011;76:74538-9.
4. AORN Recommended Practices for Preoperative Patient Skin Antisepsis. In: Burlingame B, Denholm B, Link T, Ogg MJ, Spruce L, Spry C, et al., editors. Guidelines for Perioperative Practice. Denver, CO: AORN, Inc. Published online January 2016, doi: 10.6015/psrp.15.01.043.
5. Marecek GS, Weatherford BM, Fuller EB, Saltzman MD. The effect of axillary hair on surgical antisepsis around the shoulder. J Shoulder Elbow Surg 2015;24:804-8.
6. Ferriman D, Gallwey JD. Clinical assessment of body hair growth in women. J Clin Endocrinol Metab 1961;21:1440-7.
7. Edmiston CE, Spencer M, Lewis BD, Brown KR, Rossi PJ, Henen CR, et al. Reducing the risk of surgical site infections: did we really think that SCIP would lead us to the promised land? Surg Infect (Larchmt) 2011;12:169-77.
8. Alexander JW, Fischer JE, Boyajian M, Palmquist J, Morris MJ. The influence of hair removal methods on wound infections. Arch Surg 1983;118:347-52.
9. Hogan MA, Piatt JH. Shaving of the scalp may increase the rate of infection in CSF shunt surgery. Pediatr Neurosurg 1997;26:180-4.
10. Tanner J, Norrie P, Melen K. Preoperative hair removal to reduce surgical site infections. Cochrane Database Syst Rev 2011;(11):CD004122.
11. Mishriki SF, Law DJ, Jeffery PJ. Factors affecting the incidence of postoperative wound infection. J Hosp Infect 1990;16:223-30.
12. Tanner J, Moncaster K, Woodings D. Preoperative hair removal: a systematic review. J Perioper Pract 2007;17:118-21.
13. Mangram AJ, Horan TC, Pearson MI, Silver LC, Jarvis WR. Hospital Infection Control Practice Advisory Committee. Guidelines for the prevention of surgical site infection, 1999. Infect Control Hosp Epidemiol 1999;20:247-78.
14. Edmiston CE, Seabrook GR, Cambria RA, Brown KR, Lewis BD, Sommers JR, et al. Molecular epidemiology of microbial contamination in the operating room environment: is there a risk for infections? Surgery 2005;138:572-88.