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Perioperative hair removal: A review of best practice and a practice improvement opportunity

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Abstract

The current practice of perioperative hair removal reflects research-driven changes designed to minimize the risk of surgical wound infection. An aspect of the practice which has received less scrutiny is the clean-up of the clipped hair. This process is critical. The loose fibers represent a potential infection risk because of the micro-organisms they can carry, but their clean-up can pose a logistical problem because of the time required to remove them. Research has demonstrated that the most commonly employed means of clean-up, the use of adhesive tape or sticky mitts, can be both ineffective and time-consuming in addition to posing an infection risk from cross-contamination. Recently published research evaluating surgical clippers fitted with a vacuum-assisted hair collection device highlights the potential for significant practice improvement in the perioperative hair removal clean-up process. These improvements include not only further mitigation of potential infection risk but also substantial OR time and cost savings.

Keywords

Perioperative hair removal / Vacuum-assisted hair collection / Perioperative efficiency / Perioperative infection control / Perioperative practice improvement

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Introduction

Efforts to reduce the incidence of surgical wound infections have resulted in a number of changes to the practice of perioperative hair removal. Evidence pointing to the impact that method, timing, and physical location of hair removal have on infection rates has led to new recommendations from professional organizations such as the Centers for Disease Control and Prevention (CDC) and the Association of periOperative Registered Nurses (AORN) as well as accrediting bodies such as The Joint Commission (TJC) and Centers for Medicaid and Medicare Services (CMS). While all of these groups have concluded that hair at the surgical site should be left in place whenever possible, the practice of hair removal continues to be undertaken in many procedures, and not always in accordance with guideline recommendations (Xi & Pearson 2015).

Even when the guidelines are followed, the practice has infection prevention implications for the patient and can be onerous for staff who must spend valuable time physically removing the clipped hair. This clean up time, taken cumulatively, can present a significant barrier to optimizing perioperative efficiency. A recently published study, however, has demonstrated that a new technology can potentially transform this practice by reducing the time required to clip and clean up residual hair and significantly diminish the microbial burden associated with clipped loose hair (Edmiston et al 2016). This literature review discusses the research behind current best practice and the potential for practice improvement.

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Practice issues: To remove or not to remove?

Perioperative hair removal dates back to the 1700s, although it is not entirely clear what the original reasons for the practice were (Altman 1983, McIntyre & McCloy 1994). By the early 20th century, however, the primary reason was to reduce the risk that microorganisms in hair could cause postoperative wound infections, with hospitals even hiring barbers to shave the operative sites (Altman 1983). Additionally, hair could not only obscure the surgical incision site but also interfere with sutures and wound dressings (Kumar et al 2002, JBI 2007). The concerns about hygiene and infection risk, along with the desire for unimpeded access to the surgical incision site, are the predominant reasons for perioperative hair removal today (Kumar et al 2002, Tanner et al 2011).

The concerns about infection risk have been fed by evidence demonstrating the presence of pathogenic microorganisms in hair (Summers et al 1965, Noble 1966, Dineen & Drusin 1973, Boyce 2014). In their 1960s study, Summers et al recovered bacteria from the hair of all 164 patients and staff members tested and found *Staphylococcus aureus* (*S.aureus*) to be the most common pathogen isolated (27.4%) (Summers et al 1965). They further documented that the incidence of staphylococcal wound infections was higher among hair carriers than in the non-carrier group (Summers et al 1965). In a study published the following year, Noble demonstrated that 10% of individuals tested, who had no contact with a hospital, carried *S. aureus* in their hair (Noble 1966). More recently, Jahns and Alexeyev noted that 60% of 194 'normal skin' biopsies from healthy subjects revealed microbial colonization of hair follicles and/or stratum corneum (Jahns & Alexeyev 2016).

Most significantly, healthcare-associated infection (HAI) outbreaks have been traced to organisms from the hair or scalp (Dineen & Drusin 1973, Mastro et al 1990). Dineen and Drusin linked an outbreak of *S.aureus* surgical HAIs among 11 patients to a surgeon colonized with the same phage type of *S.aureus* in his hair, but not in his nose, throat, skin or subungual spaces (Dineen & Drusin 1973). They also demonstrated a link between a nurse colonized with *S.aureus* on scalp lesions and an outbreak of HAIs on a transplant ward (Dineen & Drusin 1973). Similarly, Mastro et al reported an outbreak of *Streptococcus pyogenes* infections traced to scalp lesions on an operating room (OR) technician (Mastro 1990). More recently, Rahav et al reported an outbreak of *Mycobacterium jacuzii* surgical wound infections in 15 women undergoing breast implant surgery that was traced back to the surgeon whose hair had been colonized from a whirlpool (Rahav et al 2006). While these reports describe infection resulting from hair shedding, they further underscore the fact that human hair can potentially harbor pathogens.

Subsequent research, however, has demonstrated that perioperative hair removal can potentially compromise the skin barrier depending on the method of hair removal employed. The compromised barrier creates a portal of entry for skin microorganisms, some of the most common pathogens associated with nosocomial infections (DeGeest et al 1995, Mangram et al 1999, Celik & Kara 2007, Adisa et al 2011, Tanner et al 2011). A sentinel 10 year prospective study of 62,939 wounds conducted by Cruse and Foord demonstrated that the lowest risk of surgical wound infection was associated with no preoperative hair removal (Cruse & Foord 1980). This laid the groundwork for recommendations from the Centers for Disease Control and Prevention, Association for PeriOperative Registered Nurses, and the National Institute for Health and Care Excellence (NICE) that perioperative hair removal should not be performed unless the hair at or around the incision site will interfere with the surgical procedure (Mangram et al 1999, NICE 2008, AORN 2014).

Method

Shaving vs clipping

Despite the recommendation to leave surgical site hair in place whenever possible, perioperative hair removal is still a relatively common practice, particularly for orthopedic, cardiovascular, OB/GYN, abdominal and neurosurgical procedures (Xi & Pearson 2015). This is often a practitioner-specific practice, rooted in how a surgeon was trained. Another factor contributing to the practice is the fact that, in the presence of hair, alcohol-based skin antiseptics may require extended dry times (up to an hour), adding considerable length to patient preparation time if the hair is not removed.

While early hair removal practices commonly involved either clipping or shaving, multiple studies over the past three decades have demonstrated less damage to skin and lower surgical wound infection rates with clipping than with shaving (Cruse & Foord 1980, Alexander et al 1983, Ko et al 1992, Kjϕnniksen 2002, Dellinger et al 2005, Trussell et al 2008, Graf et al 2009, Tanner et al 2011, Lefebvre 2015, Markatos et al 2015, Lefebvre 2015) Research has shown that razor shaving creates micro-abrasions in the skin, allowing skin-dwelling micro-organisms to proliferate (Mangram 1999, Celik & Kara 2007, Adisa et al 2011, Tanner et al 2011). These micro-organisms can then migrate into the incision site, causing surgical wound infections (Mangram et al 1999). As Tanner et al (2011) demonstrated (see studies identified by Tanner et al in Table 1), there is abundant evidence supporting lower surgical wound infection rates when hair is removed via clipping as opposed to shaving.

Additionally, two large reviews, further concluded that surgical wound infection rates were lower when clipping

Table 1 Examples of studies demonstrating lower surgical wound infection rates when hair is clipped *versus* shaved (Tanner et al 2011)

Evidence Study	Infectionrate Razor	Infection rate Clipper
Liau et al (2010)	3.1%	0.5%
Graf et al (2009)	3.6%	1.8%
Trussel et al (2008)	3.5%	1.5%
Dellinger et al (2005)	2.3%	1.7%
Alexander et al (1983)	6.4%	1.8%
Ko et al (1992)	1.31%	0.6%
Cruse and Foord (1980)	2.5%	1.5%

was performed for perioperative hair removal vs shaving (Niel-Weise et al 2005, Tanner et al 2011).

As a result, United States and international guidelines overwhelmingly recommend the use of clippers over razors when perioperative hair removal is necessary (NICE 2008, AHRQ 2009, TJC 2013, Anderson et al 2014, AORN 2014). A recent survey of 250 AORN members indicates that these recommendations are being followed as 98% of respondents indicated that they were clipping rather than shaving patients (Xi & Pearson 2015). An analysis of perioperative skin removal methods by NICE actually concluded that, despite the fact that razors are often a less costly option for hair removal, when all costs including those for treating surgical wound infections were factored into the analysis, clipping with electric clippers was both more effective and less costly (NICE 2008).

Clipping technique

Clipping technique is also critical to optimal outcomes associated with perioperative hair removal. Accrediting agencies require that manufacturer's directions for surgical clippers, including direction, angle and blade type, are taught to surgical personnel and are followed (CMS 2014, TJC 2014). They also require documentation of competency for each employee who will use clippers. Improper technique can result in raking of the skin, causing significant damage and, subsequently, a portal for infection.

Timing

The timing of hair removal has also been thought to play a role in surgical wound infection risk. Some studies have demonstrated that removing hair on the day of surgery or immediately before surgery results in lower surgical wound infection rates than hair removal the day before surgery (Alexander et al 1983, Ko et al 1992, IHI 2012). This is thought to be because the longer bacteria have in the rich growth environment of the micro-abraded tissue, the greater the opportunity for proliferation and the higher the resulting bioburden (McIntyre & McCloy 1994).

In their guidelines for the prevention of surgical site infection, the CDC highlights four studies which demonstrate a significantly lower surgical wound infection rate for clipping immediately before surgery (1.8%) compared with clipping the night before (4%) (Mangram et al 1999). Accordingly, perioperative hair removal the day of surgery is recommended by both the CDC and AORN (Mangram et al 1999, AORN 2014). It should be noted, however, that in the most recent Cochrane review of randomized controlled trials evaluating timing of perioperative hair removal, Tanner et al did not find a significant effect of the timing of hair removal on SSI rates (Tanner et al 2011). They did note that the 'comparison is underpowered and we cannot exclude the possibility of an effect' (Tanner et al 2011).

Location

Because clipping results in the dispersal of hair fibers that can potentially contaminate the operative field, the CDC, AORN and Institute for Healthcare Improvement (IHI) recommend that hair clipping be performed outside of the operating room (Mangram et al 1999, AORN 2014, IHI 2016). This could also be viewed as a more efficient practice, as the lengthy clean-up process can occupy valuable OR time. Nonetheless, surveys and observational data have indicated that the majority of clipping is still occurring inside the OR (Xi & Pearson 2015). In the above-mentioned survey of 250 perioperative nurses from different facilities, 60% of respondents reported clipping inside the OR, citing a number of reasons for the practice: surgeon preference, patient privacy, reduced potential for delays, emergency situations, and preference for clipping while the patient is under anesthesia (Xi & Pearson 2015).

Clean-up

As hair is clipped, loose fibers are dispersed around the surgical field and surrounding area. These fibers represent both a potential infection risk in the OR because of the micro-organisms they can carry and a logistical problem because of the time required to collect/remove them. If removed in the area, hair can settle on linens, wheels and the floor and may inadvertently be transported into the OR. In the survey of AORN members, respondents reported ranking complete removal of hair clippings as important as controlling OR traffic in terms of reducing surgical wound infection risk in their personal perception (Xi & Pearson 2015). Table 2 shows respondents' reported clean-up methods.

Adhesive tape

The most commonly employed tools, adhesive tape and sticky mitts, though generally easy to use and readily available, have a number of associated problems. Neither is always effective in removing hair from wheels

Table 2 Survey of 250 AORN members regarding clipped hair clean-up method* (n = 250) (Xi and Pearson 2015)

Clean-up method	Survey respondents
Adhesive tape	88%
Sticky mitt	26.4%
Wet gauze/cloth	6%
Vacuum suction	1.6%

Respondents were asked to check all that apply

Image 1. Example of visible contamination of adhesive tape rolls

and sticky mats. In the same survey, respondents estimated on average that only 71% of hair was collected using tape (Xi & Pearson 2015). Tape rolls are also not provided as single-use or sterile items and are rarely kept under controlled conditions to prevent environmental or high touch contamination. Observational reports suggest that tape rolls are often placed in scrub pockets or even hung on stethoscopes potentially exposing them to cross-contamination as seen in Image 1. In the aforementioned survey, 70% of OR perioperative nurses reported 'sometimes or always' noticing contamination of the tape roll (Xi & Pearson 2015).

In an Australian study, Harris et al collected partially-used adhesive tape from three different hospitals and documented microbial contamination of all collected specimens, including contamination with multi-drug resistant organisms such as vancomycin-resistant enterococcus (VRE) and methicillin-resistant *Staphylococcus aureus* (MRSA) (Harris et al 2012). They noted the visible contamination of the sides of many of the rolls which they theorized could pose a larger threat than contamination of the circumferential surface of the tape. They surmised that this was because rolls are often placed on their side when stored and are coated with a sticky residue that may facilitate particulate and bacterial adhesion. As such, they further postulated that removing a portion of the circumferential surface of the tape prior to use would not reduce contamination risk as the majority of

Image 2. Vacuum-assisted hair collection device used in Edmiston et al's study

bacteria are likely found on the side surface (Harris et al 2012). These study results support earlier work conducted in the 1970s and 90s.

Berkowitz et al cultured new rolls of adhesive tape prior to placement in an intensive care unit and then again on days 1, 5, and 7. They found that, not only were 100% of the rolls contaminated with opportunistic bacteria, but that a number of the rolls had migrated to at least one different location within the unit (Berkowitz et al 1974). In a 1999 study Redelmeier and Livesley cultured tape samples from rolls throughout a large hospital and found 74% to be colonized with pathogenic bacteria (Redelmeier & Livesley 1999).

It could be argued that the risk of cross infection from a contaminated tape roll to a patient undergoing perioperative hair removal is small, given that the patient has not yet had an incision made. There are a number of problems associated with this means of hair collection, however, including the fact that a core principle of standard infection prevention and control measures aimed at reducing the transmission of healthcare-associated pathogens is, in the words of Weber and Rutala, 'not shar[ing] patient care items between patients unless the items have been cleaned and disinfected between use and are labeled as appropriate for multiple-patient use' (Weber & Rutala 2013). Furthermore, hair fibers have been shown to disperse over a wide area and use of a contaminated 'tool' to collect those fibers close to the surgical site, potentially in a location on the patient's body that does not undergo skin preparation, is far from ideal when the goal is to achieve as sterile a peri-incisional environment as possible. Finally, tape can damage soft, friable skin through skin stripping and micro-abrasions, potentially creating a portal for infection. The adhesive component can also cause adverse skin reactions in some individuals, not to mention tears or rips in gloves used to handle the tape.

Another problem associated with adhesive tape for hair clean-up is the significant waste associated with one-time usage of a typical 10-yard roll. Further, when a roll of tape is used on a one-time basis to avoid the cross-contamination issues, the resultant waste can be significant. A study of 46 discharges from 20 patient rooms on a pediatric oncology floor found that among all rolls of tape collected at discharge, the average usage from a 10 yard roll was only one yard (Harris et al 2012). Extrapolating this rate to their entire hospital's annual activity, they estimated an annual wastage of 73 miles of tape (Love 2013).

Another study evaluating tape usage upon discharge from rooms on a medical-surgical floor found an average usage rate of two yards per 10 yard roll (Love 2013). Projecting this usage rate to that hospital's activity would result in an annual wastage of 53 miles of tape (Love 2013). Given the contamination risks and waste potential, Harris et al concluded their article on tape contamination with the recommendation that 'Short rolls of surgical adhesive tape should be supplied in sealed packets and used for individual patients, only after hand disinfection, and discarded after use' (Harris et al 2012).

Time for clean-up

Surgical clipping clean-up also has significant logistical implications for OR efficiency and throughput when it is performed in the OR. Room set up, including preparing the patient and instrument table, must be delayed until hair clean-up is finished. The survey of AORN members reported that the average amount of time devoted to hair clean-up was 4.1 minutes per case (Xi & Pearson 2015). With one minute of operating room time costing an average of \$62 (range \$22-\$133)/£20-£24.77) according to several reports, the cumulative cost of that clean-up time over the course of a day could be considerable (NHS 2009, Macario 2010, Ang et al 2016).

A new alternative: Existing research on a novel approach

To address the issues of minimizing particle dispersion and reducing clean-up time for perioperative hair removal, Edmiston et al (2016) reported on a surgical clipper system fitted with a vacuum-assisted hair collection device (SCVAD) as seen in Image 2. The system involves a single use suction port that attaches to standard surgical clippers and is connected via tubing to a one-and-a-half-pound portable vacuum unit with a surgical grade filter. The filter is a latex-free, single-use, disposable filter which captures the vacuumed product (eg hair and airborne particles) in a filter body reservoir. After clipping, the filter is disposed and the tubing and nozzle, which are plastic, can either be recycled as such or also discarded. The vacuum can be shared between clipper sets located in different ORs or individual vacuums can be placed in multiple ORs.

Edmiston et al compared three major outcomes

1. Total time required to clip and clean-up residual hair with standard surgical clippers (SSC) and adhesive tape vs the SCVAD
2. Quantity of dispersed hair and associated microbial burdens after clipping with SSC compared with the SCVAD, and
3. Degree of skin irritation after clipping with both devices (Edmiston et al 2016).

Additionally, perioperative nurses who performed the clipping and clean-up were queried as to how they perceived the efficacy and comfort of use for the SCVAD (Edmiston et al 2016). In the study, trained registered nurses clipped the chest or groin of 18 males, clipping a randomized side of the chest or groin with a SSC and the other side with a SCVAD (Edmiston et al 2016). Settle plates were used to measure hair particulates and microbial contamination before and during clipping. Total time for clipping and clean-up with both devices was tracked. Skin assessment prior to and after clipping with both devices was performed using a mexameter to measure skin erythema and a tewameter to assess transepidermal water loss (TEWL) (Edmiston et al 2016).

The results of the study were impressive, suggesting the SCVAD technology could play a valuable role in perioperative hair removal. Total clipping and clean-up time with the SCVAD was 36% shorter for the groin area and 49% shorter for the chest area than with the SSC ($P < 0.001$) (Edmiston et al 2016).

Additionally, recovered hair particulates ($P<0.001$) and microbial contamination ($P<0.003$) were both significantly lower with the SCVAD than with the SSC (Edmiston et al 2016). The researchers recovered significantly fewer loose hair fibers ($P<0.001$) in both settle plates and airborne particulate samplers when the SCVAD was utilized compared with SSC followed by surgical tape clean-up of clipped hair fibers (Edmiston et al 2016). Both devices produced the same skin changes from baseline erythema as measured with the mexameter, but the SSC 'produced a significantly ($P < 0.001$) higher measured change in TEWL at chest test sites compared with use of the SCVAD' (groin skin assessments were not made), suggesting possible damage to the barrier function of the epidermis (Edmiston et al 2016). Study nurses reported noting both an observational increase in speed of clipping and clean-up as well as an overall enhanced 'cleanliness following the clipping process' (Edmiston et al 2016). Additionally, study subjects reported less discomfort for both the clipping process and collection of clipped loose hair with the SCVAD than with the SSC (NL 2011).

Practice implications

As discussed, surgical hair clippings can contain skin cells and a variety of micro-organisms which, when scattered around the operative field, represent a potential infection risk. Use of adhesive tape, the most common means of removing these dispersed particles, has been demonstrated to have its own infection risks. Cross-contamination of tape rolls, whether from use for multiple patients or unclean storage, can expose a patient to additional microbes when the tape is applied to hair on the skin or other areas within the operative field. Tape can also cause skin irritation, potentially compromising the skin barrier. Use of a vacuum that collects an average of 98.5% of clipped hair and debris down to 0.3 micrometers (NL 2011) could significantly facilitate the cleaning process, particularly when considering that a single hair strand is typically 75 micrometers and a red blood cell is 5 micrometers in diameter (BW 2016).

Over the past decade, operating room efficiency has become a major focus of healthcare improvement efforts in the current constrained fiscal climate. Hospitals have been scrutinizing a wide range of metrics from contribution margins per OR hour to turnover times in an effort to optimize efficiency (Macario 2006, Seim et al 2006). In their article 'Statistical process control as a tool for monitoring nonoperative time' Seim et al demonstrated a 40% reduction in nonoperative time when 'a perioperative workflow wherein many activities occur in parallel, rather than following each other sequentially' was established (Seim et al 2006). Edmiston et al clearly demonstrated that consolidating hair clipping and clean-up into a one-step process is more time-efficient and effective in achieving the end result of maximum hair retrieval (Edmiston et al 2016).

Furthermore, hair clipping clean-up is a notoriously unpopular task among perioperative nurses. Providing professional staff with an effective means of accomplishing this task and freeing them to provide other aspects of care may result in greater employee satisfaction and, thus, an opportunity for employee empowerment. In their February 2016 article in *Nursing Leader*, Scanlon and Woolfords' reported how empowering their frontline employees to effect positive change for patient safety and practice improvement led to 'remarkable improvements in quality, patient experience, professionalism, engagement, and overall care delivery' (Scanlon & Woolfords 2016).

Finally, the substantial time savings realized over the course of a day could translate into considerable financial savings as well. Using the previously mentioned estimates of $62/£20-£24.77 per OR minute and the reported average of 4.1 minutes spent cleaning hair clippings for an OR that had two procedures a day (involving clipping) five days a week, one could conceivably realize $10,168 (£3,280-£4,062) monthly/ or $122,016 (£39,360-£48,747) annually in savings (NHS 2009, Macario 2010, Ang et al 2016). These savings would clearly be significantly higher with each additional OR in a facility utilizing the technology and would undoubtedly outweigh both the necessary equipment and staff training costs, both of which are currently subsidized by the manufacturer. Clearly, the savings could be even more significant with higher case-loads requiring clipping. As Edmiston et al state in their study of this new technology, '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' (Edmiston 2016).

Conclusion

As AORN's 2016 *Perioperative Efficiency Toolkit* states, 'Opportunities exist to improve patient safety... minimize delays and waste, increase operating room use, and enhance the perioperative experience for the patient and family, as well as for the perioperative team members' (AORN 2016). Historically, issues have been present in terms of infection control associated with different methods of perioperative hair removal. Edmiston et al's (2016) study suggests that vacuum-assisted perioperative hair clipping could indeed represent one of these opportunities by potentially enhancing both infection control and efficiency.

By providing both valuable infection prevention and time benefits, vacuum-assisted surgical hair clipping may indeed be the next significant practice change for perioperative hair removal. Further study evaluating this technology should be done in order to develop a more robust body of evidence. However, this early data, weighed against the current problems associated with perioperative hair removal, suggests that this technology holds considerable promise in the future of the practice.

Conflict of interests

Charles Edmiston and Denise Graham acknowledge receiving payment from CareFusion for consulting services.

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