Securing the Endotracheal Tube With Adhesive Tape: An Integrative Literature Review

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The practice of securing the endotracheal tube with adhesive tape appears to be benign. However, evidence-based research suggests it is a high-risk practice. Common elements for the taping practice include the tape, anesthesia gas machine, and anesthesia provider. Researchers have found that adhesive tape outside its original packaging became contaminated with pathogens. The bacteria found on the tape included Pseudomonas, Escherichia coli, Klebsiella, Enterobacter, coagulase-positive staphylococci, methicillin-resistant Staphylococcus aureus and vancomycin-resistant enterococcal organisms. In addition, a patient does not need to have direct contact with the anesthesia gas machine for pathogen transmission to occur. Anesthesia providers were identified as the origin of bacterial transmission in 12% of cases, with pathogens on their hands 66% of the time. Unfortunately, anesthesia providers are often noncompliant with hand hygiene. They failed to practice hand hygiene 82% of the time. Last, the tape can drop to the floor and harbor pathogens despite cleaning 41.6 % of the time; it is often retrieved and reused. All the common elements, independently and collectively, involve the tape and its potential to increase the patient's exposure to pathogens and the risk of infection. This literature review presents evidence-based research regarding endotracheal tube taping practice to ensure patient safety.

Keywords: Anesthesia, anesthesia equipment, contamination, disinfection, hand hygiene.

Before anesthesia delivery, the anesthesia provider prepares the anesthetic location to ensure the functionality and availability of equipment and supplies. Commonly, nonsterile adhesive tape is cut and adhered to the anesthesia gas machine. The tape will be used to secure the endotracheal (ET) tube to the patient's face on induction of general anesthesia. At first glance, this practice of securing the tape appears to be a benign task. However, evidence-based research suggests that this may not be the case. In fact, securing the ET tube in this manner could be a high-risk practice. The common elements of this practice are the tape, the anesthesia gas machine, and the anesthesia provider. The purpose of this literature review is to present the best evidence-based research regarding the practice of taping the ET tube to ensure patient safety. This article highlights the most apparent gaps in our knowledge regarding pathogen transmission. Alternatives to the current tape products are also explored.

Literature Review

• ***Search Strategy.*** The identification of the best current evidence involved searches of the following online electronic databases: MEDLINE/PubMed, The Cochrane Library, Cumulative Index to Nursing & Allied Health Literature (CINAHL), and SUMSearch. To capture the largest number of relevant citations available, a manual search was conducted of the reference lists of all articles obtained from any reports of research not already identified. Guidelines from professional, national, and international organizations were reviewed. The US Food and Drug Administration (FDA) Medical Device Classifications, the Centers for Disease Control and Prevention (CDC) guidelines, and the US *Federal Register* were searched, as well. The following keywords and word strings were used alone and in combination: *anesthesia, anesthesia equipment, contamination, disinfection, hand-hygiene*, and *operating room*. The international literature search was limited to English-language articles published between 1974 and 2013. Items were included for review if the literature addressed 1 or all the common elements, which are the tape, the anesthesia gas machine, and the anesthesia provider. Unpublished reports, research, and findings were not used.

The first-stage screening eliminated more than 1,000 published items because of design concerns that focused on treatments of surgical site infection (SSI), anesthesia breathing equipment, tape tensile strengths, and local anesthetic techniques. Items that included pediatric patients were included if 1 or all 3 the common elements were the focus of the item. Preoperative antibiotic administration unrelated to anesthesia delivery had the most items that were eliminated because this topic was not relevant to the problem under study. During the secondary screening, all editorials and commentaries that did not offer research findings from an original study of the author

were eliminated because of their lower level of evidence. Guidelines from professional and national agencies were retained for reference as secondary sources but were not used for the critical appraisal of the literature. The search yielded 31 items that met the inclusion criteria. They were appraised and leveled using a 7-level hierarchy as adapted from the work of Melnyk and Fineout-Overholt,[1] in which evidence levels range from level 1 (systematic reviews) to level 7 (expert opinion). Many of the items overlapped the common elements of the taping practice. Still, there was a minimum of 6 items addressing each of the elements. All had evidence levels ranging from level 1 to level 7.

Four articles disclosed potential conflicts of interest. One author noted in 2 articles served as a consultant for Ecolab Inc, Steris Corp, and the American Society for Healthcare Environmental Services (now called the Association for Healthcare Environment). Two authors of another article are members of the boards of MSD and Astellas Pharma and have received speaker's fees from Gilead Sciences Inc and MSD. The fourth author of 1 article is a paid employee of Bode Chemie GmbH & Co KG in Germany.

• ***Impact and Need for Prevention.*** Hospital-acquired infections (HAIs) pose a major concern to our patients. Approximately 440,000 patients develop HAIs annually in the United States, with SSIs and *Clostridium difficile* infections reported with the most frequency (36% and 30.3%, respectively).[2] Although all patients with HAIs have an extended hospital stay, patients with methicillin-resistant *Staphylococcus aureus* (MRSA) have the longest stay, with an additional 15.7 to 23.0 days, respectively.[2] The annual costs associated with the major HAIs approach $9.8 billion (95% CI, $8.3-$11.5 billion).[2] Furthermore, Zimlichman et al,[2] in their meta-analysis on the costs associated with HAIs, report that as many as 75% of HAIs were preventable. These findings have a financial impact on hospitals and providers, with higher expenses, reduced reimbursements, and penalties. Patients are greatly troubled by HAIs, as well. Minimally, HAIs affect their lives with loss of quality of life, added pain and suffering, and loss of function.

Pathogen exposure and pathogen transmission is a serious reality for hospitalized patients. Our current use of adhesive tape for securing the ET tube adds to this reality. Although our current taping practice appears benign, research reveals that it exposes the patient to pathogens and pathogen transmission.[3-7] Every opportunity to reduce the incidence of pathogen transmission through prevention needs to be incorporated into the provision of anesthesia care. Although the causal relationship between HAIs and the taping practice has not been determined, research reveals that surface contamination with the transmission of pathogens contributes to the development of HAIs[8(p687)] and that the relationship between intraoperative anesthetic management and HAIs is evolving.[9] The severity of the consequences associated with HAIs prohibits a delay in preventive interventions because of a lack of a causal relationship. Research demonstrates that there is more success with preventing HAIs than with determining the cause of HAIs.[8] As well, there is widespread acceptance of the need to prevent the spread of potential pathogens through preventive interventions.[10] A better taping practice must be implemented to reduce the risk of pathogen exposure and pathogen transmission, to ensure patient safety.

The delivery of anesthesia requires a brief, intense, and often critical relationship with the patient. Patients depend on their anesthesia provider to protect them from exposure to threats by employing preventive interventions. This is the expectation even when the threat is not apparent to them. Biddle,[11] in his integrative review, notes that feedback regarding our care of the patient is sometimes lacking and not immediately known. His examples include peripheral nerve injuries, cognitive impairment, episodes of awareness under anesthesia, and infections.[11(p231)] The taping practice that is used to secure the ET tube must be added to this list because of the risks associated with the adhesive tape and the current taping practice.

Anesthesia providers have an important role to play in preventing pathogen exposure and pathogen transmission. The practice of taping the ET tube is a modifiable risk factor related to the anesthesia practice. Guidelines for the taping practice have not been developed. With accepted best practices for infection prevention and control incorporated into the taping practice, anesthesia providers must lead in this effort to advance patient safety in this area.

• ***Guidelines, Standards, and Mandates for Tape.*** The first and most important element of the taping practice is the tape. Surgical adhesive tape is a Class 1 medical device, according to the FDA.[12] It does not achieve its purpose through a chemical action in or on the body. As a Class 1 medical device, it is subject to the least regulatory control. It does not support or sustain life or disability, and may not present an unreasonable risk of illness or injury.[12] The CDC classifies items as critical, semicritical, and noncritical.[13] Tape meets the definition of a noncritical item that has "virtually no risk".[13] The Association of periOperative Registered Nurses (AORN) Perioperative Standards and Recommendations coincide with FDA and the CDC by noting that a noncritical item "comes in contact with intact skin but not with mucous membranes, sterile tissue, or the vascular system."[14(p479)] The AORN Perioperative Standards and Recommendations further state that "anesthesia equipment should be clean at the time of use."[14(p475)] For noncritical items, the AORN recommends low-level disinfection between patients, defined as a process by which most bacteria, some

viruses, and some fungi are killed.[14] The process may not kill resistant organisms, such as *Mycobacterium tuberculosis* or bacterial spores.[14(p478)] Unfortunately, surgical adhesive tape disintegrates with low-level disinfection.

Overall, the requirements for tape are few and are broadly approached except for one mandated use. The US Centers for Medicare and Medicaid Services (CMS) has determined standards and guidelines for tape when used for end-stage renal dialysis recipients as a means to prevent the transmission of infections among these patients. As published in the *Federal Register*, the CMS states that "rolls of tape cannot be decontaminated and can serve as a source of contamination for both the facility personnel and patients."[15(p20376)] Furthermore, the CMS mandates: "Tape rolls must be dedicated to a single patient, or disposed of after patient use."[15(p20376)] To date, end-stage renal dialysis recipients are the only patient group required to have a dedicated tape roll because of their susceptibility to opportunistic infections.

Guidelines, standards, and recommendations apply to surgical adhesive tape. However, the tape cannot withstand the decontamination process of low-level disinfection. Thus, surgical adhesive tape is not decontaminated between patients: it is usually simply reused without further consideration except for end-stage renal dialysis recipients. Overall, direction for the safe handling of surgical adhesive tape for patients is lacking.

• ***Contamination of Adhesive Tape in the Clinical Setting.*** Tape is used to secure the ET tube because it is durable, easy to remove, and nonirritating to the skin. It is packaged as clean, nonsterile, and in 11.1-m (10-yd) rolls. It is often stored on a shelf of the anesthesia gas machine or in a drawer of the anesthesia gas machine. Under normal circumstances, it is not discarded at the end of a surgical case. Usually the roll of tape returns to the supply bin for use on other patients. Redelmeier and Livesley[3(p373)] note that "adhesive tape is a unique piece of medical equipment because it is almost never washed or sterilized after initial opening of the package. It may be used by and for many individuals and thereby become exposed to several patients and clinicians." Dyro and Shepherd,[16(p134)] clinical engineers, add that "white (medical) adhesive tape is used inappropriately in association with medical devices, to make temporary repairs or to placard a warning or instruction." As well, adhesive tape is commonly used to secure intravenous (IV) cannulas, surgical drains, and wound drains.[4,5]

The evidence consistently found pathogens on the currently available adhesive tape. Many researchers found that adhesive tape became contaminated once outside its original packaging. The bacteria found on the tape in these studies included *Pseudomonas, Escherichia coli, Klebsiella, Enterobacter*, coagulase-positive staphylococci, MRSA and vancomycin-resistant enterococcus, coagulase-negative staphylococci, and *Micrococcus* spp.[3-7]

A 7-day bacteriologic survey of adhesive tape being used in a 16-bed intensive care unit of a 560-bed teaching hospital revealed that only 8 of 23 rolls of tape yielded pure cultures.[6] These authors, Berkowitz et al,[6] noted that the organisms fell into 2 main groups. The first included those commonly found on environmental areas and normal skin. The second group consisted of gram-negative bacilli, which are often isolated from the hospital environment and are frequently found to produce disease in hospitalized individuals.[6(p653)]

Cady et al[4] performed a small, pilot bench study to evaluate bacterial contamination of IV tape and found that 14 of 24 pieces of tape on agar plates had pathogens and fungi. This was reported as an editorial in a professional anesthesia newsletter. Her group noted, "There was bacterial growth along nearly every piece of tape regardless of whether they were placed on the agar plates in a sterile or nonsterile manner."[4(p1)]

Harris et al,[5] in a bacteriologic survey conducted in 3 hospitals in Australia, found that 11 of 21 tape batches contained pathogens, specifically MRSA or both MRSA and vancomycin-resistant enterococcus. As well, they found that "all batches showed evidence of contamination with other bacteria such as *Bacillus cereus*, coagulase-negative staphylococci, nonmultiresistant Enterobacteriaceae, *Pseudomonas* spp, *Acinetobacter* spp, and other enterococci.[5] These findings were reported in an editorial in an Australian medical journal.

Redelmeier and Livesley[3] conducted their bacteriologic survey in one hospital. They theorized that the adhesive tape used to secure IV catheters may be contaminated and contribute to IV catheter infections. They collected adhesive tape from various hospital locations and reported that more than 74% of them were colonized with pathogenic bacteria. "Coagulase-negative staphylococci were the single most common bacteria."[3(p374)] Although tape from the inner layer showed fewer colony formations (2 of 42 specimens) compared with from the outer layer (59 of 80 specimens), the difference was significant ($P < .001$) and supported the conclusion that the concern for infection was valid.[3] They stated, "Together, these results indicate that adhesive tape may transmit pathogenic bacteria that contribute to infections."[3(p374)]

Lipscombe and Juma[7] conducted a prospective clinical trial comparing bacterial growth on 2 tapes after their application to the intact skin. Although the study demonstrated that there was no significant difference ($P = .18$) in bacterial growth beneath the nonsterile 3M Micropore tape and the sterile Steri-Strip (3M) that was applied to the skin, it did report colony-forming units (CFUs) from the 3M Micropore tape (24.07 ± 4.10 CFUs) and from the Steri-Strip (19.77 ± 3.30 CFUs).[7] The main organisms isolated from the cultures were coagulase-negative staphylococci and *Micrococcus* spp.[7]

Coagulase-negative staphylococcal bacteria include

Staphylococcus epidermidis, *Staphylococcus haemolyticus*, *Staphylococcus saprophyticus*, and *Staphylococcus lugdunensis*. They had been considered common environmental findings until recently. Recent reports from cardiology, neurology, and orthopedics have demonstrated that these bacteria are the cause of deep SSIs.[17] Until now, the source of the infection was thought to be from the patient's own skin. Recent studies of the epidemiology of coagulase-negative staphylococci support the probability that the infections develop as a result of coagulase-negative staphylococci from the operating room gaining access to the patient's wound during surgery.[17(p359)] Kramer et al[18] report, in their systematic review, that gram-negative bacteria can persist as long as 7 months. Kaye et al[19] found that in their matched-outcomes study of 1,337 elderly surgical patients, the most common SSI pathogen was *S aureus* (n = 275; 51.6%). Among *S aureus* isolates, 58.2% were methicillin- resistant.[19(p4)] These evidence-based reports of coagulase-negative staphylococci on the adhesive tape must be concerning for anesthesia providers.

Wilcox et al[20] provide insight into the survivability and virulence of *S aureus* in the retrospective analysis of a 5-year outbreak of MRSA, *S aureus phage* 53,85 (SA5385), in a regional neonatal unit that affected 202 babies. Despite numerous interventions, including hand hygiene, incorporation of various disinfectants, nasally administered mupirocin for the babies, and separation of the babies, the infection continued. At one point, it was feared that the unit would need to close. One last intervention was implemented. This was to aseptically handle the Stomahesive (Bristol-Myers-Squibb), a neonatal skin protectant that prevents skin abrasion from adhesive tape removal. According to Wilcox et al,[20] "Successful control of the outbreak was only achieved after deficiencies in the handling of a skin protectant material were identified and a new protocol instigated." Amazingly, the use of the adhesive permitted the survival of *S aureus* for at least 71 days.[20]

Mucormycosis is a severe opportunistic fungal infection that poses a great threat to the survival of patients. In a literature review of 169 patients, Rammaert et al[21] differentiate between common mucormycosis and healthcare-associated mucormycosis and focus on the latter, as it is associated with healthcare procedures. They found that the skin was involved in 96 of 196 (57%) cases with 10 of 33 (58%) premature infants and 39 of 69 (56%) surgical patients.[21] Cutaneous mucormycosis was linked to various adhesives, including tape, skin patches, and adhesives on urine bags, temperature probes, and electrodes. "Indeed, the rupture of the skin barrier was associated with the majority of [healthcare-associated mucormycosis], especially after surgical procedures."[21(pS50)] This diagnosis is serious and associated with poor outcomes. Rammaert et al[21(pS46)] found that the mortality rate was 50% (84 of 169 patients died), but was higher when treatment did not combine antifungal drugs and surgery (50% [29 of 58] vs 38% [34 of 90]; $P = .142$) and in neonates (64% [23 of 36] vs 46% [61 of 133]; $P = .055$).

The evidence confirms that the tape used to secure the ET tube serves as a source of pathogens that are transmitted to the patient. The pathogens are numerous, persistent, and opportunistic. Exposing patients to these pathogens unnecessarily can be detrimental to the patient's safety.

• ***Anesthesia Gas Machine and Equipment Contamination Despite Disinfection.*** The anesthesia gas machine serves as the second element of the taping practice. Once cut from the roll, the tape is secured to the anesthesia gas machine for use on induction of the anesthetic. Numerous studies have concluded that a patient does not need to have direct contact with the anesthesia gas machine for pathogen transmission to occur.[8,10,11,18,22,23] Baillie et al[10] found in their observational study of 8 operating rooms in a UK general hospital that after between-case disinfection of the anesthesia gas machine, 6% of anesthetic machines continued to harbor potentially pathogenic bacteria such as *S aureus* and gram-negative bacilli on them (5 of 77 cultures [6%; 95% CI, 1.0%-12%; $P = .03$]). They reported that the likely contaminated items on the machines included the flow control knobs, vaporizer dials, and the breathing system bags.[10]

Loftus et al,[9] in their prospective pilot study of 61 randomly selected operating rooms, reported that the adjustable pressure-limiting valve and agent dials intraoperatively became contaminated at case conclusion above that of baseline controls, with a mean increase of 115 colonies per surface area sample (CPSS; $P < .001$). They reported, "For workspace contamination, the probability increases to greater than 50% when CPSS is more than 100 which occurred in 30% of the cases".[9(p402)] They suggest that the bacterial transfer to patients is associated with the variable aseptic practice of the anesthesia providers. They conclude that the anesthesia machine is likely to play a role in microbial contamination of patients.

In a prospective, randomized, observational study of 274 operating rooms, Loftus et al[24] reported that stopcock transmission events with contamination occurred in 23% (126 of 548) of the cases, with 14 between-case and 30 within-case transmission events confirmed. They found that the environment, rather than the provider's hands, was the likely source of the stopcock contamination (relative risk [RR] = 1.91, confidence interval [CI], 1.09-3.35; $P = .029$) or patients (RR, 2.56, CI, 1.34-4.89; $P = .002$).[24]

Munoz-Price et al[25] found in their environmental study at a 1,500 bed, county teaching facility that despite disinfection, 12.5% of the surfaces continued to have pathogens in their 43 operating rooms ($P = .998$). The pathogens recovered included gram-negative bacilli, *S aureus*, and *Enterococcus* spp. Anesthesia-related equip-

ment that was studied included the keyboards, knobs, switches, oxygen reservoir bags, and adjacent medication drawers.

Reporting of CFUs and CPSS are important measures in microbiology where viable bacteria or fungal numbers are noted. For patients receiving total joint replacement, a CFU measure of 10 has been found to cause deep infection.[26,27] Otter et al,[8] in their review, report that contaminated surfaces have a strong potential to result in pathogen transmission. Although the presence of pathogens does not indicate the cause of infection solely, it does matter when considering that the environmentally associated nosocomial dose of pathogens to cause an infection can be low.[8] They reported that "less than 15 *S aureus* cells were sufficient to cause infection in experimental lesions, less than 1 CFU/cm² was sufficient to cause *C difficile* in mice, and a single norovirus particle is thought to have the capacity to cause infection."[8(p689)] Furthermore, this finding confirms that contaminated surfaces transmit pathogens that can be detrimental to patients. The surfaces of the anesthesia gas machine and the equipment share in the contamination.

• ***Provider Noncompliance With Hand Hygiene.*** The anesthesia provider's application of the tape to the patient's face using his or her hands is the third element of the taping practice. The concern with this element focuses on hand contamination, the inadvertent transmission of pathogens, and hand hygiene as a measure to prevent the pathogen transmission. Bacterial transmission during the delivery of anesthesia occurs often and is serious. As described by Baillie et al,[10] the induction of general anesthesia requires that the anesthesia provider have contact with the patient's mouth, nose, and upper airway, which includes secretions and possibly small amounts of blood. It seems obvious that hand hygiene would be an integral part of providing anesthesia care. Yet, often hand hygiene is ineffective and anesthesia providers are noncompliant.[28,29]

Loftus et al,[22] in their prospective observational study in 28 operating rooms, found that bacterial contamination of the operating room environment occurred in 89% of cases (146 of 164) studied. Most importantly, the study identified the providers as the origin of the transmission in 12% of the cases (17 of 146)."[22(p101)] In addition, the study found MRSA, vancomycin-resistant enterococcus, methicillin-sensitive *S aureus, Enterococcus*, and Enterobacteriaceae on the hands of the providers 66% of the time.

Hand hygiene is important to reduce the transmission of pathogens. The American Association of Nurse Anesthetists (AANA) embraces hand hygiene as a priority item, as noted in the *AANA Infection Control Guide for CRNAs*.[30] Unfortunately, only when providers identify their need for self-protection does proper hand hygiene occur. The research of Borg et al[31] and Erasmus et al[32] affirms this sentiment. In their qualitative study of 2,725 surveyed workers in 8 Mediterranean countries, Borg et al[31] found that hand hygiene was practiced when the workers' hands were visibly dirty (93.6% [95% CI 92.7%-94.5%]), when their patient had MRSA or other resistant organisms (93.3% [95% CI, 92.4%-94.2%]), and (93.3% [95% CI, 92.1-94%]) if they had direct close contact with a patient.

Erasmus et al[32] highlighted the importance of positive role models in the adoption of and compliance with hand-hygiene practices in their qualitative study that was conducted on 65 healthcare professionals in 5 Dutch hospitals. They reported that negative role models influenced others to abstain from compliance with hand-hygiene guidelines.[32]

At minimum, hand hygiene should occur before and after patient exposure, according to most guidelines. Unfortunately, few studies report this. Most studies have results such as those of Randle et al[33] and Krediet et al.[34] Randle and associates[33] completed a 24-hour observational study, which found that hand washing occurred 68% (196 of 290) of the time before patient contact and 80% (114 of 142) after a patient contact. Krediet and her associates,[34] in their observational study conducted in a university medical center in the Netherlands, found that providers used hand hygiene at lower levels, only 2% (7 of 363) on entering the operating room and 8% (28 of 333) after leaving the operating room.[34] Munoz-Price et al,[28] in their quality improvement project in a 1,500-bed public teaching hospital affiliated with a university, observed that during an 8-hour period, the anesthesia providers performed only 13 hand disinfections but touched 1,132 objects. Biddle and Shah[29] performed an observational study of anesthesia providers over a 4-week period in which 7,976 opportunities for hand hygiene occurred and found that the failure rate ranged from 64% to 93%, with a mean aggregate failure rate of 82%.

Despite efforts to incorporate hand hygiene into anesthesia practice, the evidence confirms that hand contamination, inadvertent transmission of pathogens, and poor hand hygiene are associated with the current taping practice.

Discussion

• ***Gaps in Knowledge.*** The trail of adhesive tape that we use for securing the ET tube to the patient's face can now be tracked. It has been documented to be stored on the shelf of the anesthesia gas machine or stored in a drawer of the gas machine. It is used on the patient, but typically the roll is not discarded. Rather, it is returned to a supply bin for use on another patient. Additionally, we have found evidence that the adhesive tape drops to the floor at times, is retrieved, and used again. Unless the tape is visibly soiled, there is no indication of its prior history, exposure, use, or location. As well, there is no requirement for documentation of its travels. Directions and

guidelines regarding the safe handling and application of the surgical adhesive tape have not been developed for the anesthesia provider.

Contamination of the tape through inadvertent dropping to the floor was addressed indirectly in the research of Munoz-Price et al.[25] Her group observed, "Objects fall onto the operating room floors and are frequently placed back either on the horizontal work surfaces or on patients themselves."[25(p8)] This study determined that 41.6% of the floor samples continued to have gram-negative bacilli identified after educational and environmental services interventions (P = .108). In summary, they reported that the operating room floor could potentially transmit organisms to the patient through inadvertent contamination of surfaces during routine care.[25(p7)]

Munoz-Price et al,[28] in another quality improvement project, records her surprise as she witnessed the anesthesia providers having contact with objects from the floor, which did not follow with hand hygiene. In this study, it was observed 17 times.[28] Clearly, retrieval of items from the operating room floor for reuse on the patient needs to be avoided and discouraged. Measures are needed to identify whether the tape is clean or contaminated so that anesthesia providers may avoid unnecessary pathogen exposure to the patient.

One example of the hand-hygiene opportunities identified in Biddle and Shah's[29] observational study of 7,976 hand hygiene opportunities was "Hand cleansing after retrieving a soiled or dropped item off the operating room floor". They recorded the failures of hand hygiene in the "other" category, a catchall collection of behaviors. Tape was the second item in this category. They noted that a roll of tape is one of those items that falls to the floor, is picked up, and used.[29(p758)] Evidence confirms that pathogens are present both on the tape and on the floor.[25] Targeted research studies examining the pathogens and pathogen transmission associated with specific uses of the tape for patient care in the operating room, before use by anesthesia providers, have not been undertaken. Areas of research interest should include the tape used for the patient's hair removal after clipping, tape used to secure the patient's position for surgery, and the tape used for equipment repair.

Associating adhesive tape with immunocompromised patients is rarely discussed among anesthesia providers unless they are presented with a patient receiving an immunosuppressant for cancer, with human immunodeficiency virus (HIV) or an autoimmune disease, or before organ and tissue transplantation. However, perhaps it needs to be. Patients who have endocrine, gastrointestinal, hematologic, iatrogenic, infectious, nutritional, renal, rheumatologic, and other chronic diseases all have immunodeficiency.[35] Surgery and anesthesia are now known to induce a general immune response in most patients.[36] These patients have an increased risk for pathogen transmission in the operating room.[9,29] The FDA must have recognized this when it mandated dedicated tape rolls for end-stage renal dialysis recipients, with disposal of the tape after use[15]; these patients are often immunocompromised and are susceptible to infections. To date, there are no regulations or guidelines regarding adhesive tape practice for other immunocompromised patients. This important concern needs to be addressed.

Overwhelmingly, research confirms that the adhesive tape and the current taping practice expose the patient to pathogens and pathogen transmission. Until recently, the possibility of contaminated surfaces transmitting pathogens was considered inconsequential. Otter et al[8(p696)] report, "There is now compelling evidence that contaminated surfaces make an important contribution to the epidemic and endemic transmission of *C difficile*, vancomycin-resistant enterococcus, MRSA, *Acinetobacter baumannii*, and *Pseudomonas aeruginosa* and to the epidemic transmission of norovirus." The presence of pathogens matter when considering that the nosocomial dose of pathogens to cause an infection can be low.[8] Conclusive findings confirming the relationship between colonies of bacteria and the cause of infection are lacking.[8] A causal relationship between HAIs and the taping practice has not been reported. Nonetheless, the evidence of pathogens combined with scientific knowledge becomes the foundation for developing improved taping practices. Further research to determine the causal relationship might be indicated for scientific purposes to address these gaps in knowledge. Meanwhile, the benefits of delaying preventive interventions related to the current taping practice need substantiation in light of the potential for development of HAIs and their association with pathogens.

- ***Alternatives to Current Tape Products.*** An alternative tape for securing the ET tube on induction would be approximately 76.2 cm (30 in) long, have good adhesive quality, and be hypoallergenic, latex free, durable, and disposable. Most importantly, it would be for single-patient use, and each tape roll would be individually packaged. For securing the ET tube, it would need to be clean but not sterile. Currently, there are 4 tape products on the market for securing ET tubes, but not all of them meet the criteria for preventing pathogen transmission during the practice of taping. Two of the products can be packaged as clean and nonsterile in individual bags or wraps in short lengths. Most anesthesia providers use Durapore tape, a 3M product. It is available in shorter lengths. Unfortunately, the tape rolls are not individually packaged. A precut, foam adhesive ET tube holder (ET Tape, B&B Medical Technologies Inc) is marketed for patients who require a few days of ventilator support and involves being wrapped around the patient's neck. This tape meets the previously stated criteria, but there are 4 pieces to assemble, which makes the product cum-

bersome to apply quickly. A zinc oxide adhesive tape (Hy-Tape, Hy-Tape International Inc) is marketed for longer-term ventilator patients and for short-term patients such as those in the operating room, and it can be packaged individually. The drawback with this product is that individually packaged tape is available only when it is part of a kit. The last product is TrioMed Antimicrobial Medical Adhesive Tape (TrioMed Corp). This tape has an antimicrobial agent engineered into it that it is 99.99% effective[37] against many pathogens, including resistant organisms. Unfortunately, FDA approval is pending on the product; therefore, it is not available in the United States yet. The real alternatives at this time appear to be Hy-Tape and ET Tape.

Summary

Preparing the anesthetic location for the delivery of anesthesia by the anesthesia provider is a prerequisite to the administration of anesthesia. In this literature review, the evidence-based research concludes that the current taping practice is a high-risk practice. The evidence confirms that the tape is contaminated, the anesthesia gas machine is contaminated despite disinfection, and anesthesia providers suboptimally practice hand hygiene, leading to contamination. All of these common elements, independently and collectively, involve the tape and its potential to increase the patient's exposure to pathogens through the taping practice. These increase the pathogens transmitted to the patient and increase the patient's risk of HAI. Gaps in the knowledge of pathogen transmission remain. Additional in-depth research is needed.

Of the tape alternatives available, 2 products meet the criteria for an alternative tape in that they are prepared clean and individually packaged: Hy-Tape and ET Tape. The current taping practice must change to prevent pathogen transmission and to ensure patient safety.

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