GAUZE BANDAGES WITH A BOUND ANTI-MICROBIAL POLYMER SUPPRESS BACTERIAL GROWTH IN PATIENTS WITH HEAVILY EXUDATING WOUNDS
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Abstract
Gauze bandages and pads are commonly used as dressings for patients with large wounds. However, a disadvantage of gauze bandages is the absorption of exudate into the dressing. Exudates absorb contributions to the development of high levels of bacteria in BIOGUARD bandages.

A new gauze bandage with a bound antimicrobial polymer was used instead of standard gauze bandages in the treatment of three patients. Two of these patients were suffering from Toxic Epidermal Necrolysis Syndrome (TENS) with thermal injury of approximately 90% total body area (TBSA). The third patient had full thickness thermal burns of greater than 70% TBSA.

Within 24 hours of applying standard gauze bandages to the wounds, the dressings developed a metallic green color and strong odor, characteristic of Pseudomonas aeruginosa. In marked contrast, antimicrobial gauze dressings applied to the wounds adjacent to the standard gauze dressings had no visible evidence of bacterial fouling.

The following clinical results suggest that antimicrobial polymers may prevent rapid bacterial growth in gauze dressings saturated with heavy exudates. The reduction in bacteria could lead to a decrease in the contamination of open wounds, as compared to standard dressings. Additional benefits of using antimicrobial gauze dressings may include reduced wound odor, frequency of dressing changes, and spread of bacteria from fouled dressings to the patient and clinical personnel.

Background
The dangers of bacterial colonization in wounds are well understood by caregivers – particularly because compromised surfaces are the primary ports of vulnerability for the patient. Antimicrobial barrier dressings optimize efficacy and safety to provide caregivers the ability to safely apply the dressings prophylactically to help prevent pathogen transfer.

Other currently available antimicrobial dressings are designed to aggressively treat colonized wounds (see section on Zone of Inhibition and Figure 3) by leaching antimicrobial agents into the wound bed. This approach is successful in reducing wound colonization, but released small antimicrobial molecules may be ineffective for bacterial resistance, cause skin discoloration / reaction, or impede wound healing (Wang et al, 2009; Silver et al, 2003; Van Den Plas et al, 2008). Additionally, the coating of many current antimicrobial dressings keeps them out of reach of many patient populations for regular use. Antimicrobial polymer dressings were designed to provide an antimicrobial barrier technology that is effective, economical, and safe enough for broad application.

Mechanism of Antimicrobial Activity
The BIOGUARD™ antimicrobial barrier dressing is based on the patented NIMBUS® technology (Quick-Med Technologies, Inc.). The active antimicrobial agent is permanently bound to the dressing surface, and acts on the wound pathogen by physically disrupting the prokaryotic cell wall. The macromolecular agent responsible for this mode of action is poly(diallyldimethylammonium chloride), or polyDADMAC, a cationic quaternary ammonium polymer. Gilbert and Moore (2005) describe the mechanism of cell wall disruption induced by polymeric cationic biocides in excellent detail as shown graphically in Figure 1. The cationic polymer chains coordinate to the anionic segments of the phospholipid membrane, displacing stabilizing calcium ions. As increasing numbers of cell membrane molecules coordinate to the polymer, the integrity of the bacterial membrane is compromised, leading to gaps and holes as shown in the image.

The bound antimicrobial protects the dressing without leaching any chemical agents into the wound bed, and therefore nothing toxic that could retard healing enters the wound bed. Also, the absence of a leached agent ensures the absolute minimum possibility for bacteria to develop resistant strains.

Antimicrobial Testing
Wound pathogen ATCC number of species Average % kill vs. untreated control, t=0 Average % kill vs. control, overnight Staphylococcus aureus ATCC 6538 99.99995% 99.999995% Staphylococcus epidermidis ATCC 12238 99.99997% 99.999977% Pseudomonas aeruginosa ATCC 15442 99.9999% 99.9999% Enterococcus faecalis ATCC 19434 99.999999% 99.999999% Aerococcus viridans ATCC BAA-1699 99.999999% 99.999999% Acinetobacter baumannii ATCC 19606 99.99995% 99.999999% VRE (Vancomycin resistant Enterococcus faecium) ATCC 51299 99.99996% 99.999999% Table 1: Cytotoxicity

Testing Summary
Test Type Test Method Results for BioGuard

Clinical observations
The use of cotton based dressings for wound care has been a standard for many years. One of the inherent issues related to this type of dressing is the inability to control the growth of pathogens as the dressing absorbs exudate.

Recently, gauze with a bound antimicrobial polymer was trialed on three patients that presented with wounds covering greater than 70% total body surface area. Two of these patients were suffering from Toxic Epidermal Necrolysis Syndrome (TENS) with epidermal involvement of approximately 90% total body area (TBSA). The third patient had full thickness thermal burns of greater than 70% TBSA. Standard gauze was initially applied and within 24 hours, the dressing developed a metallic green color and strong odor, characteristic of Pseudomonas aeruginosa. After removal of the contaminated dressings and application of the BIOGUARD, there was no noted evidence of bacterial fouling on the antimicrobial dressings.

After treatment of heavily exuding wounds with BIOGUARD antimicrobial dressings, the clinical results suggest that the use of BIOGUARD could lead to reduction in bacteria and decrease in the contamination of open wounds, as compared to standard dressings.

References
1. ASTM F895-84 "Standard test method for agar diffusion cell culture screening for cytotoxicity". 2. Silver S. Bacterial silver dressings demonstrate high microbial efficacy (≥log10 kill) against common wound pathogens, while maintaining the highest possible level of biocompatibility in the laboratory testings. This is most clearly illustrated by Zone of Inhibition testing: the lack an inhibitory zone confirms that BIOGUARD antimicrobial barrier dressing is able to control pathogens in the dressing without exerting a physiological effect on the wound bed. A silver dressing tested alongside showed a zone of inhibition, and retarded growth of cultured mouse fibroblasts. Initial clinical observations at Shands Burn Center were very positive. Multiple experiences Burn Unit nurses noted a reduction in exudate color and odor in patients treated with BIOGUARD as compared to standard gauze dressings. Further clinical trials are being discussed to show efficacy.

Fig 4a shows a Donor Site treated with the standard gauze dressings that are metallic green in color and a strong odor is present. Figure 4b shows the same Donor Site after 24 hours of treatment with the BIOGUARD gauze bandages. It is apparent that the exudate is present but the color and odor have improved.

Fig 5a shows a Donor Site treated with BIOGUARD gauze bandages and it is apparent that there is a large amount of exudate present, the dressings are not green in color and, based on the observational trial, are odor free. Discussion on Gauze, dressings or bandages with an antimicrobial dressing. Alegria-Gonzalez, M.F., et al. Wounds 2009; 21 (4): 157-166.

Fig 6: Conceptual Representation: action of polymeric cationic biocidal agent

Fig 7: Exemplary Scanning Electron Microscope images of E. coli (left) and a Gauze wound dressing and on BIOGUARD wound dressing (as labeled). E. coli bacteria grown in contact with cotton substrate had intact membranes and full rod shape. E. coli exposed to BIOGUARD surfaces show clear membrane damage and altered general morphology. Some bacteria also show abnormal rods and indentations with losing intracellular content.

Fig 8: Comparison of exudate / bacterial growth: a) Gauze dressing and b) BIOGUARD dressing. Significant difference in inflammation and infection with use of BIOGUARD.

Fig 9: Comparison of Gauze and BIOGUARD dressing. Significant difference in inflammation and infection with use of BIOGUARD.

Conclusions
The BIOGUARD dressing demonstrated high microbial efficacy (≥log10 kill) against common wound pathogens, while maintaining the highest possible level of biocompatibility in the laboratory testings. This is most clearly illustrated by Zone of Inhibition testing: the lack an inhibitory zone confirms that BIOGUARD antimicrobial barrier dressing is able to control pathogens in the dressing without exerting a physiological effect on the wound bed. A silver dressing tested alongside showed a zone of inhibition, and retarded growth of cultured mouse fibroblasts. Initial clinical observations at Shands Burn Center were very positive. Multiple experiences Burn Unit nurses noted a reduction in exudate color and odor in patients treated with BIOGUARD as compared to standard gauze dressings. Further clinical trials are being discussed to show efficacy.

In summary, these in vitro data show that BIOGUARD dressing provides a highly effective antimicrobial barrier function without damaging cells that are essential for wound healing. Initial clinical experience indicate that BIOGUARD dressing reduces bacterial biofilm in dressings on heavily exuding wounds. Future clinical studies will compare bacterial loads in BIOGUARD dressing and standard gauze dressing in wounds to assess the impact on healing and infection of wounds in vulnerable patients.

Figure 1: Conceptual Representation: action of polymeric cationic biocidal agent.

Figure 2: ( above) Scanning Electron microscope images of E. coli (left), exudate induced gauze wound dressing and on BIOGUARD wound dressing (as labeled). E. coli bacteria grown in contact with cotton substrate had intact membranes and full rod shape. E. coli exposed to BIOGUARD surfaces show clear membrane damage and altered general morphology. Some bacteria also show abnormal rods and indentations with losing intracellular content.

Figure 4a: Gauze Dressing with exudate / bacterial growth: a) Gauze dressing and b) BIOGUARD dressing. Significant difference in inflammation and infection with use of BIOGUARD.

Figure 4b: Comparison of Gauze and BIOGUARD dressing. Significant difference in inflammation and infection with use of BIOGUARD.

Figure 5a: Comparison of exudate / bacterial growth: a) Gauze dressing and b) BIOGUARD dressing. Significant difference in inflammation and infection with use of BIOGUARD.

Figure 6: Conceptual Representation: action of polymeric cationic biocidal agent.