

MILITARY APPLICATIONS OF SILVER-NYLON DRESSINGS

David J. Barillo, MD, FACS, FCCM
Winchester Medical Center
Winchester, VA, USA

INTRODUCTION:

Medical support of military operations involves treatment of massive soft tissue wounds, burns, open fractures, blast injuries and traumatic amputations under conditions that are often austere and far from supply lines. Combat Support Hospitals presently deployed in Iraq and Afghanistan are designed for stabilization and rapid transfer of injured patients back to the United States, but are often tasked with the long-term treatment of local populations when injured. The rapid evacuation of military patients back to the United States means that patients cannot be kept for observation, and must be handed off between multiple teams of care providers during evacuation. The long-term management of injured host-nation patients is difficult because of personnel and supply limitations. For example, routine dressing changes often cannot be performed at bedside and must be taken to the operating room. In these situations, a simple anti-microbial dressing that can be used by inexperienced personnel for multiple different types of wounds would be very useful.

The pathogens encountered in military practice are increasingly multi-drug resistant. Resner et al in a study of pathogens responsible for bacteremia in burn patients involved in combat operations overseas found that the traditional pathogens (*Staphylococcus aureus* and *Pseudomonas aeruginosa*) are increasingly being supplanted by multi-resistant *Acinetobacter* and *Klebsiella* species (1). Topical therapy applied to open war wounds must be effective against multi-resistant flora.

Elemental silver as the free ion has been utilized as an anti-microbial agent for hundreds of years. Dilute silver nitrate solutions have been employed as topical burn therapy since 1965 (2,3) and silver-sulfadiazene has been a mainstay of burn management since 1968 (2,4,5). Silver ion is bactericidal against over 150 species of bacteria, viruses, yeast and fungi, including Methicillin-resistant *Staphylococcus aureus* (MRSA) and multi-drug resistant (MDR) *Acinetobacter*, *Klebsiella* and *Pseudomonas* species. Silver-nylon dressings that release ionic silver have been commercially available for many years. For management of large burns, silver-nylon dressings are often changed once every three days, rather than the twice-a-day dressings required when mafenide acetate or silver sulfadiazene cream is used, representing significant savings in personnel time and dressing materials. Certain silver-nylon dressings are approved by the US Food and Drug Administration for up to 7 days of use and this can result in even greater time and material savings.

There is significant variation in silver content and release rates between different products. The silver content of the product currently in use by the US military is 50 to 100 times higher than some other brands of silver dressings presently on the market. The constant delivery of silver ion at these high levels means that clinically significant microbial resistance does not occur.

In this study, we retrospectively reviewed published reports of the medical evaluation or clinical use of silver-nylon dressings to determine if silver-nylon dressings can function as a universal wound dressing for military use.

METHODS:

A Medline literature review for the years 1997 thru 2010 was conducted, searching for English-language articles written by military medical personnel on the subject of silver-nylon dressings. A total of 15 articles were found and reviewed (references 6-20).

The personal experiences of the author in using silver-nylon dressings as a deployed military burn and trauma surgeon and as a flight surgeon responsible for the safe trans-continental aero-medical evacuation of severely injured or burned soldiers was also reviewed.

RESULTS:

English-language literature review for the years 1977-2010 produced 15 publications describing the laboratory or clinical use of silver-nylon dressings in military burn or combat applications (6-20).

The US Army Institute of Surgical Research / US Army Burn Center, located at Brooke Army Medical Center in San Antonio, Texas has published multiple studies on the effects of silver-nylon dressings. In the 1980's and early 1990's the Army Burn Center researched the effects of weak direct current on burn and wound healing (6-14). The electrodes used to apply electrical current were constructed of a silver-nylon cloth originally developed for use as a radar reflector (6). As a serendipitous finding, it was discovered that the silver-nylon dressings themselves possessed significant anti-microbial properties, which was attributed to the release of silver ion. While this research was being carried out, several companies were independently developing burn dressings that released ionized silver. When silver-nylon burn dressings became commercially available, the US Army Burn Center became an early adopter of this technology for both burns and for acute and chronic wounds.

Brandt et al documented the first combat use of silver-nylon dressings in 2003 (17,18). In Afghanistan, the 452nd Combat Support Hospital (CSH) was deployed in 2003 to Bagram Airbase, 47 kilometers north of Kabul. The hospital operated 44 in-patient beds in tents (17). Burned troops from the US or NATO countries were usually stabilized and evacuated out of country, however, local nationals with burn injury often required treatment at the CSH for prolonged periods of time. Over several months, the CSH treated 10 burn patients including 8 children and an additional 8 patients with complex wounds from mine injuries including 4 children. Silver-nylon dressings were extensively utilized. Dressings were left in place for 3 to 7 days and reused for a total of 7 days (17,18). Use of an every 3-7 day dressing change instead of a twice-daily silver sulfadiazene dressing change 'appeared to decrease the total workload associated with burn wound care' (17). There were no episodes of cellulitis or burn wound infection associated with the use of silver-nylon in this setting (17,18).

Cancio et al (17) described the use of silver-nylon dressings at the 28th Combat Support Hospital (CSH) in Iraq. Deployed to Baghdad in the initial phases of Operation Iraqi Freedom, the 28th CSH operated from April 11, 2003 to August 26, 2003 in tents on an austere logistics base. During this period, the CSH was designated as the primary in-theater burn facility. Of the 1867 patients admitted to the hospital, there were 86 burn patients, comprising 5% of all admissions (17). These included 42 US military or coalition patients and 44 Iraqi Nationals. The average length of stay was 2 days for military patients compared to 10 days (range 1-53 days) for Iraqi civilians (17). Of 877 operations performed at the CSH, 59 were performed for burn injury, including 49 debridements, 5 split thickness skin graftings and 4 escharotomies. As Operation Iraqi Freedom progressed, the Baghdad CSH moved into Ibn Sina Hospital, a fixed facility located within the International Zone. This hospital remained the only designated burn center in Iraq for 7 years. Over several rotations between the years 2003 and 2009, Ibn Sina was continuously staffed by US Military personnel from the 28th, 10th, 31st and 86th Combat Support Hospitals, and by surgeons from the US Army Burn Center. Silver-nylon dressings were extensively used during this timeframe for burn, blast, open fracture and other massive soft tissue injuries.

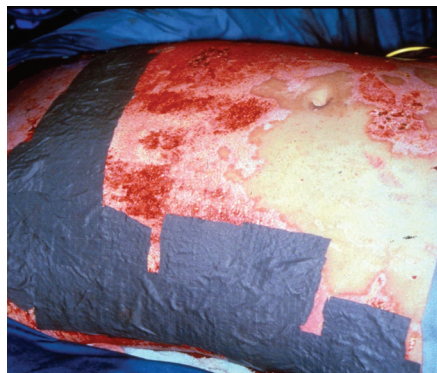
Barillo et al (19) described the use of silver-nylon dressings in flight for transcontinental aero-medical evacuation. The US Army Burn Center staffs a Burn Flight Team to facilitate long-range aero-medical transfer of patients back to the center for care, and this team frequently transported patients from Landstuhl Regional Medical Center, Germany to San Antonio, Texas, a distance of 5400 miles. During wartime operations, it was not unusual for the Burn Flight Team to transport 5 or more severely burned patients (with total burn size ranging from 50 to 90% total body surface area) on one flight. On arrival to Landstuhl Regional Medical Center, the burn team would perform a complete burn dressing change using silver sulfadiazene and mafenide acetate creams. This usually required two or more nurses and two or more hours per patient to perform. A second dressing change would be performed prior to flight the following day. With 5 patients requiring nearly 10 hours of combined dressing time, it was difficult for the team to both complete the second dressing change and to be able to depart the Intensive Care Unit at midmorning for the flight home. Since the flight would take approximately 13 hours, the patients would require another dressing change immediately upon arrival in San Antonio. To solve this problem, the Burn Flight Team began carrying silver-nylon burn dressings to Landstuhl on each flight. This allowed a single dressing change at the time of Burn Team arrival, and obviated the need for a second dressing change pre-flight the following day. Likewise, if the aircraft was delayed or diverted, there was no need for a burn dressing change in flight. The silver-nylon technique soon became the standard treatment for aero-medical evacuation. Silver-nylon burn dressings are presently positioned at every US military hospital along the evacuation route, including Landstuhl, Baghdad, Bagram Air Base and the US Air Force Expeditionary Hospital at Balad Air Base in Iraq. The technique is now also used by US Air Force Critical Care Air Transport (CCAT) Teams and is taught at the US Air Force School of Aerospace Medicine Critical Care Air Transport Basic Course.



COMPLEX COMBAT WOUND WITH OPEN FRACTURES, TRAUMATIC AMPUTATIONS AND SEVERE BURNS



SILVER-NYLON DRESSINGS APPLIED IN THE OPERATING ROOM AT A COMBAT SUPPORT HOSPITAL IN AFGHANISTAN, 2011



EXPERIMENTAL SILVER-NYLON DRESSING ("ELECTRIC BANDAGE") IN USE AT THE US ARMY BURN CENTER, EARLY 1990s



SILVER-NYLON DRESSINGS BEING PLACED BY BURN FLIGHT TEAM PRIOR TO TRANSPORT FROM LANDSTUHL, GERMANY TO SAN ANTONIO, TEXAS

DISCUSSION:

The nature of wartime medical support is changing. For most of the major conflicts of the 20th century, very large station or field hospitals could be positioned in or close to the combat zone. These were full-service general hospitals with 1000 or more beds where injured soldiers could be treated for extended periods of time. Medical planning during the Cold War relied on the availability of such facilities pre-positioned in Europe, along with robust supply chains to keep them functioning. With the downsizing of military forces that followed the end of the Cold War, it became impossible to either field or transport such large fixed hospitals. Following a joint-service streamlining of military medical forces in the 1990s, the medical facilities in present use are lighter, smaller, modular, and easier to move but are not as nearly well stocked as the old fixed facilities that they replaced. This means that patients must be rapidly stabilized and evacuated, and frequent re-supply must be carried out, involving either airlift or convoy operations thru hostile territory. In these situations, silver-nylon dressings have a clear advantage as fewer dressing supplies are required. For example, patients with burns can be treated with one dressing every 3-7 days rather than the two dressing changes a day required with either mafenide acetate or silver sulfadiazene. Silver-nylon dressings are also lighter to transport, easier to store and less affected by environmental extremes during storage compared to conventional cream-based dressings. While initially fielded for burn care, silver-nylon dressings have also proven useful for the management of massive soft tissue injuries, open fractures, blast injuries and traumatic amputations.

For these reasons, silver-nylon products are ideal for military applications where the number of trained medical personnel may be limited, supply lines may be tenuous and storage conditions are unpredictable.

SUMMARY:

For military medical planners, the end of the Cold War has produced new threats and new challenges. Successful medical response will require new solutions and new technologies. The pathogens seen in wartime injuries continue to evolve, and the facilities utilized for deployed medical care are now modular and mobile, but less able to provide comprehensive or extended medical care. Logistics trails are longer and aero-medical evacuation, of necessity, must occur much more quickly.

Silver-nylon dressings are effective, easy to use (particularly by inexperienced personnel), easy to store and easy to transport. Because they can be used for multiple indications, silver-nylon dressings are a true force multiplier and should be considered an essential medical product for both military and civilian (disaster response) applications.

REFERENCES:

- 1) Resner, RA, Murray, CK, Griffith, ME, Rasnake, MS, Hosenpahl, DR & Wolf, SE. Outcomes of bacteremia in burn patients involved in combat overseas. *J Am Coll Surg* 2008;206:439-444
- 2) Barillo DJ. Topical antimicrobials in burn wound care: a recent history. *Wounds* 2008; 20 (7): 192-198
- 3) Moyer, CA, Bremiano, L, Gravens, DL, Margraf, HW, Monillo, WW Jr. Treatment of large human burns with 0.5% silver nitrate solution. *Arch Surg* 1965; 90:812-867
- 4) Fox, CL Jr. Silver sulfadiazene: a new topical therapy for *Pseudomonas* in burns. *Therapy of Pseudomonas infections in burns*. *Arch Surg* 1968; 96 (2):184-188
- 5) Stamford, W, Rappole, BW, & Fox, CL, Jr. Clinical experience with silver sulfadiazene, a new topical agent for control of pseudomonas infection in burn patients. *J Trauma* 1969; 9 (5): 377-388
- 6) Chu, CS, McManus, AT, Pruitt, BA, Jr & Mason, AD, Jr. Therapeutic effects of silver-nylon dressings with weak current on *Pseudomonas aeruginosa*-infected burn wounds. *J Trauma* 1988;28:1488-1492
- 7) Chu, CS, McManus, AT, Okerberg, CV, Mason, AD Jr & Pruitt, BA Jr. Weak direct current accelerates split-thickness graft healing on tangentially excised second degree burns. *J Burn Care Rehabil* 1991;12: 283-293
- 8) Chu, CS, Matylevich, NP, McManus, AT, Mason, AD Jr, & Pruitt, BA Jr. Direct current reduces wound edema after full thickness burn injury in rats. *J Trauma* 1996; 40 (5):738-742
- 9) Chu, CS, Matylevich, NP, McManus, AT, Pruitt, BA Jr & Goodwin, CW. Direct current reduces accumulation of Evans Blue albumin in full thickness burns. *J Trauma* 1999; 47 (2): 294-299
- 10) Matylevich, NP, Chu, CS, McManus, AT, Mason, AD Jr & Pruitt, BA Jr. Direct current reduces plasma protein extravasation after partial thickness burn injury in rats. *J Trauma* 1997; 43 (5): 804-812
- 11) Chu, CS, Matylevich, NP, McManus, AT, Pruitt, BA Jr & Goodwin, CW. Optimized mesh expansion of composite skin grafts in rats treated with direct current. *J Trauma* 1997; 43 (5): 804-812
- 12) Chu, CS, McManus, AT, Mason, AD Jr, Okerberg, CV & Pruitt, BA Jr. Multiple graft harvestings from deep partial thickness scald wounds healed under the influence of weak direct current. *J Trauma* 2000; 30 (8): 1044-1050
- 13) Chu, CS, McManus, AT, Matylevich, NP, Mason, AD Jr & Pruitt, BA Jr. Enhanced survival of autoperfused-alloperformed composite grafts in allogeneized animals by use of silver-nylon dressings and direct current. *J Trauma* 1995; 39 (2): 273-278
- 14) Chu, CS, Matylevich, NP, McManus, AT, Goodwin, CW & Pruitt, BA Jr. Accelerated healing with a mesh autograft/alloperformed composite skin graft treated with silver nylon dressings and without direct current in rats. *J Trauma* 2000; 49 (1): 115-125
- 15) D'Avignon, L, Saffie, JR, Chung, KK & Cancio, LC. Prevention and management of infections associated with burns in the combat casualty. *J Trauma* 2008;64:S277-S286
- 16) Albrecht, MC, Renz, E, Calico, LC, White, CE, Blackburne, LH, Chung, K, Horvath, EE, Bielle, P, Baer, D, Wolf, SE, & Holcomb, JB. Comparison of SilverNylon® dressing to Xeroform gauze in the treatment of skin graft donor site wounds. Poster Session, Ann Burn Association
- 17) Cancio, LC, Horvath, EE, Barillo, DJ, Kopschinski, BI, Charter, KR, Mostafaei, AE, Bausher, TM, Bregman, ML, Brandt, MM & Holcomb, JB. Burn support for Operation Iraqi Freedom and related operations, 2003-2004. *J Burn Care Rehabil* 2005;26:151-161
- 18) Brandt, MM, Tait, MJ, Taddio, TT & Wahl, WL. Silverlon use in Afghanistan, 2003. Poster session. (Downloaded from www.silverlon.com)
- 19) Barillo DJ, Cancio, LC, Stack, RS, Carr, SR, Broger, KP, Crews, DM, Renz, EM & Blackburne, LH. Deployment and operation of a transportable burn intensive care unit in response to a burn multiple casualty incident. *Ann J Disaster Med* 2010; 5 (1):3-13
- 20) White, CE & Renz, EM. Advances in surgical care: management of severe burn injury. *Crit Care Med* 2008;36 (7) Suppl: S318-S324

This work has been made possible by an unrestricted educational / research grant from Argentum Medical, LLC, Chicago, IL USA