

Managing Residual Limb Hyperhidrosis in Wounded Warriors

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PRACTICE POINTS

- Hyperhidrosis of residual limbs often is induced by the occlusive effects of the water-resistant prosthetic liner that fits snugly over the limb.
- Commonly accepted treatments of hyperhidrosis often are less effective or poorly tolerated by these patients. The microwave thermal ablation device is a promising tool that may provide long-term relief of symptoms.

Residual limb dermatologic problems are a common concern among young active traumatic amputee patients who strive to maintain an active lifestyle. Hyperhidrosis of residual limbs is a recognized inciting factor that often contributes to residual limb dermatoses and is driven by the design of the prosthetic liner covering the residual limb. Treatment of hyperhidrosis in this population presents a unique challenge. Several accepted treatments of hyperhidrosis can offer some relief but have been limited by lack of results or side-effect profiles. Microwave thermal ablation has presented an enticing potential for residual limb hyperhidrosis.

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We live in a time when young, otherwise healthy, active-duty individuals are undergoing traumatic amputations at an exceedingly high rate due to ongoing military engagements. According to US military casualty statistics through September 1, 2014, Operation Iraqi Freedom, Operation Enduring Freedom, and

Operation New Dawn veterans have undergone a total of 1573 amputations.¹ Walter Reed National Military Medical Center (WRNMMC) is one of several military facilities that has managed the care of these unique patients returning from the many ongoing conflicts around the globe. Multidisciplinary teams composed of surgeons, anesthesiologists, physical therapists, prosthetists, and others have joined forces to provide extraordinary emergency and recovery care for these patients. Even in the best hands, however, these traumatic amputee patients often experience long-term and lifelong sequelae of their injuries. As dermatologists at this facility (S.P. was at WRNMMC for 3 years before transferring to Madigan Army Medical Center), we are often asked to assist in the management of a subset of these sequelae: residual limb dermatoses. Residual limb dermatoses such as recurrent bacterial and fungal infections, cysts, abrasions, blistering, irritant and allergic dermatitis, pressure ulcers, acroangiodermatitis, stump edema, and many others have a high prevalence in our wounded warrior population and impact both amputee quality of life and utilization of medical resources. As many as 73% of amputees will experience a variety of residual limb dermatoses at some point in their life, with the highest prevalence in younger, more active patients.^{2,3} We have observed that many, if not most, of these cutaneous problems can be attributed to or are exacerbated by hyperhidrosis of the residual limb. Hyperhidrosis in this population of patients can be related to excessive sweat production, but more commonly, it is attributed to the lack of evaporation of normal perspiration.

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Excess Sweat and the Prosthesis

To understand hyperhidrosis in amputee patients, it is important to understand the anatomy of the prosthesis. There are a variety of materials that are used to create prosthetic limbs. The most commonly used materials are a combination of plastic and carbon graphite/carbon fiber. The modern prosthetic limb uses a suspension system that attaches the prosthetic limb to the residual limb by creating a vacuum. There are several mechanisms to create this vacuum; however, they all depend on a liner that fits snugly over the residual limb. This liner-limb interface is responsible for protection, mitigation of sheering forces, and comfort, and it is the anchor for a good fit in the prosthesis. Unfortunately, this liner is the primary factor contributing to residual limb dermatologic problems. The liner usually is made of silicone or polyurethane and is designed to be water and sweat resistant; any excess water that finds its way into the liner-prosthetic interface will affect the seal of the device and cause slippage of the prosthesis.⁴ This water-resistant barrier is what induces the hyperhidrotic environment over the residual limb that is covered. These patients sweat with exertion, and because of the water-resistant liner, there is no mechanism for sweat evaporation. This leads to a localized environment of hyperhidrosis, increasing patients' susceptibility to chronic skin conditions. In addition to the dermatologic pathology of the residual limb, there are notable functional concerns caused by excessive sweating. Increased moisture due to sweating not only leads to pathologic dermatoses but also to impaired fit and loss of suction by leaking into the prosthetic-limb interface, which in turn can lead to decreased stamina in the prosthesis, falls, and in severe cases even prosthetic abandonment.⁵

Treating Hyperhidrosis

While working with wounded warriors in the dermatology, prosthetics, and wound care clinics at WRNMMC, it repeatedly became clear that our current treatment options for hyperhidrosis in this population were not routinely tolerated or efficacious. Although hyperhidrosis of the axillary or palmoplantar region is a commonly encountered problem with clear treatment algorithms and management strategies, hyperhidrosis in the setting of a residual limb following amputation is somewhat unique and without definitive permanent cure. In approaching this problem, our institution has implemented a variety of therapies to the residual limb that have been well described and effective in the treatment in the axillary region.

Topical antiperspirants (ie, aluminum chloride) are well-documented treatments of hyperhidrosis and work by the formation of a metal iron precipitate

when binding with mucopolysaccharides. These complexes cause damage to epithelial cells lining the ostia of eccrine glands, forming a plug in the lumen of the eccrine duct.⁶ Unfortunately, irritant contact dermatitis has affected the majority of our residual limb patients who have used topical antiperspirants and has led to poor compliance. Glycopyrrolate, an antimuscarinic agent, often is used with varying degrees of success. It works as a competitive antagonist blocking the acetylcholine muscarinic receptors that are responsible for the innervation of eccrine sweat glands. Several of our residual limb patients have a history of global hyperhidrosis and have responded favorably to 1- to 2-mg doses of glycopyrrolate administered twice daily. The side-effect profile headlined by xerostomia, urinary retention, and constipation has, as it often does, limited the dosing. We have observed that with the use of glycopyrrolate, these patients admit to less overall sweating but experience only a mild decrease in the cutaneous problems they experience over the residual limbs, which is likely attributed to the prosthetic liner that induces hyperhidrosis by preventing sweat evaporation from the residual limb. Patients may not be sweating as much, but they are still sweating and that sweat is unable to evaporate from under the liner.

Botulinum toxin is a common treatment of axillary hyperhidrosis and its effects on residual limbs are the same.^{5,7} Botulinum toxin types A, B, and E specifically cleave soluble N-ethylmaleimide-sensitive factor attachment protein receptor (SNARE) complexes, which prevents neurosecretory vesicles from fusing with the interior surface of the plasma membrane of the nerve synapse, thereby blocking release of acetylcholine.⁸ In inhibiting acetylcholine release, the signal for eccrine secretion is blocked. This therapy has been effective in our residual limb patients who tolerate the treatment. It typically involves the injection of 300 to 500 U of botulinum toxin type A diluted with 0.9% saline at 2 to 5 U per 0.1 mL into the residual limb.⁵ As with the other treatments, there are side effects that complicate compliance. Most residual limb treatments require 150 injections, which can be uncomfortable for this patient cohort. The majority of these wounded warriors have abnormal anatomy because of the traumatic nature of their injuries (ie, improvised explosive device attacks, artillery injury), and they often experience hyperesthesia, phantom limb pain, and notable scarring. These injections can be extremely painful, which often limits their utility. In addition, the therapy only provides 3 to 6 months of symptom relief. Our compliance rate for returning patients has not been good and we suspect that it is likely due to the discomfort associated with the injections.

Other therapies such as laser hair removal and iontophoresis have been attempted but have not yielded

great results or compliance. In addition to the limitations of these treatment methods, the residual limbs have presented their own unique set of challenges; complications have included varied anatomy of the residual limbs, scarring, sensitivities, and heterotopic ossification. Temporary remedies such as botulinum toxin injections also present logistical complications because they require repetitive procedural appointments that can be quite burdensome to attend when these patients move back home, often far away from our large military treatment facilities.

A New Therapy With Exciting Potential

With the recent advent of microwave thermal ablation technology, the potential for a different, possibly permanent treatment was discovered. Microwave thermal ablation of the eccrine coils has been proven safe and effective in the prolonged reduction of hyperhidrosis of the axillae and has presented as a potential therapy for our residual limb hyperhidrosis patient population. This technology produces heat that is targeted to a specific depth in the treated tissue while cooling the epidermis. There are various treatment levels that can be used to deliver graded intensities of heat. When the deep dermis is targeted, adnexal structures are denatured and destroyed, causing diminished or eliminated function. Eccrine sweat glands, apocrine glands, and even hair follicles are affected by the therapy. The manufacturer of the only microwave thermal ablation device on the market that is approved by the US Food and Drug Administration to treat axillary hyperhidrosis has suggested that these effects are long-term and possibly permanent.⁹ After several iterations with this technology, we have been able to successfully apply microwave thermal ablation of eccrine coils to 5 residual limbs and are excited about the promise that this technique possesses. A report of our index case will be published soon,¹⁰ and we are looking forward to launching our protocol treating traumatic lower extremity amputee patients that have hyperhidrosis with microwave therapy ablation technology here at WRNMMC.

Final Thoughts

Amputation residual limb dermatoses have a high prevalence and impact on amputee quality of life, particularly among young military members who strive to maintain a highly active lifestyle. Many of these dermatoses are directly related to hyperhidrosis of the residual limb that is covered by the prosthetic device and the liner that interfaces with the skin. Although many treatments for residual limb hyperhidrosis have been used with varying efficacy, none have offered a cost-effective or sustained response. Many of our wounded warriors in this amputee population have or will be transitioning out of the military in the coming

years. It is imperative to our government, our institution, and most importantly our patients that efforts are made to develop a more permanent and efficacious treatment application to provide relief to these wounded heroes. This amputee population is unique in that they are younger, healthier, and highly motivated to live as “normal” of a life as possible. The ability to ambulate in a prosthetic device can have a huge social and psychological impact, and providing a therapy that minimizes complications associated with prosthetic use is invaluable. We are excited about the results we have seen with the microwave thermal ablation device and feel that there is potential benefit for other amputee populations if the procedure is perfected.

It is an exciting age in medicine where technology and biology have remarkably honed our diagnostic and treatment capabilities. We hope that everyone in the dermatology community shares our enthusiasm and will continue to explore and test these new technologies to improve and better the lives of the patients we treat.

REFERENCES

1. Fischer H. A guide to U.S. military casualty statistics: Operation Inherent Resolve, Operation New Dawn, Operation Iraqi Freedom, and Operation Enduring Freedom. [http://ibiblio.org/hyperwar/NHC/CasualtyStats2014Nov.htm](http://ibiblio.org/hyperwar/NHC/CasualtyStats2014Nov/CasualtyStats2014Nov.htm). Congressional Research Service 7-5700; RS22452. Published November 20, 2014. Accessed May 13, 2016.
2. Yang NB, Garza LA, Foote CE, et al. High prevalence of stump dermatoses 38 years or more after amputation. *Arch Dermatol*. 2012;148:1283-1286.
3. Koc E, Tunca M, Akar A, et al. Skin problems in amputees: a descriptive study. *Int J Dermatol*. 2008;47:463-466.
4. Ghoseiri K, Safari MR. Prevalence of heat and perspiration discomfort inside prostheses: literature review. *J Rehabil Res Dev*. 2014;51:855-868.
5. Gratrix M, Hivnor C. Botulinum A toxin treatment for hyperhidrosis in patients with prosthetic limbs. *Arch Dermatol*. 2010;146:1314-1315.
6. Hölzle E. Topical pharmacological treatment. *Curr Probl Dermatol*. 2002;30:30-43.
7. Lee KYC, Levell NJ. Turning the tide: a history and review of hyperhidrosis treatment. *JRSM Open*. 2014;5. doi:10.1177/2042533313505511.
8. Dressler D, Adib Saberi F. Botulinum toxin: mechanisms of action. *Eur Neurol*. 2005;53:3-9.
9. Lupin M, Hong HC, O'Shaughnessy KF. Long-term efficacy and quality of life assessment for treatment of axillary hyperhidrosis with a microwave device. *Dermatol Surg*. 2014;40:805-807.
10. Mula K, Winston J, Pace S, et al. Use of microwave device for treatment of amputation residual limb hyperhidrosis. *Dermatol Surg*. In press.