

## NOTABLE NOTES

## Chemical Warfare's Most Notorious Agent Against the Skin Mustard Gas—Then and Now

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In July of 1917, the allied forces rallied against the German Empire, in a battle fought in the trenches of the Ypres salient, a highly sought-after territory of Belgium. In these critical battles of World War I, the use of chemical warfare took hold as nations began to effectively demoralize, deface, and kill entrenched defenders. Gas masks, initially developed to counteract the effects of these killers, were rendered useless against the most effective and widely used gas of the World War I, mustard gas.<sup>1</sup> Although this development was an ineffective killing agent, its notorious ability to disable opponents prompted its rampant popularity. Mustard gas was unique in its capacity to target the organ at the frontline of man's protection: the skin.

Within hours of exposure to the sulfur gas, cutaneous destruction began, initially with intense erythema, pruritus, and agonizing burning followed by progressive dissolution of the epidermal basal cells. Eventually, large yellow bullae formed and chemical burns occurred, ranging from mild to disfiguring. Damage often led to ruptured blisters, and subsequent necrotic wound infections. The vesicant effects of the mustard gas caused inflammation-induced melanocyte stimulation, initially manifesting as hyperpigmentation, with subsequent desquamation and hypopigmentation. The face, axilla, and genitalia were particularly vulnerable, owing to their higher concentrations of eccrine and sebaceous glands. At high concentrations, the mustard agent caused similar bleeding and blistering in the eyes and lungs, leading to temporary blindness and pulmonary edema.<sup>2</sup>

The effects of mustard gas incapacitated millions, and no effective countermeasure was ever found during the war. Treatment of the agent's damaging sequelae was limited, and prognosis was determined by the timing of decontamination. Exposed victims could only be washed with soap and water and have their wounds treated with 10% bicarbonate solution to detoxify the skin, and chlorinated soda to eliminate chemi-

cal remnants, acting as a disinfectant. These sterilization techniques proved effective in preventing serious infection.<sup>3</sup> Despite this, this deadly vesicant went on to claim 70% of the 1.3 million casualties inflicted by chemical warfare.<sup>1</sup> The use of sulfur mustard gas has remained ubiquitous over the past several decades, including in the Iran-Iraq war of the 1980s and its suspected use by ISIS forces in Iraq in August 2015.<sup>1</sup>

Today, sulfur mustard wound treatment remains supportive. In addition to standard decontamination, therapy includes wound debridement via lasers or aspiration needles, application of biological dressings consisting of collagen-laminated nylon, antimicrobial topical cream, and systemic anti-inflammatory agents. Use of recombinant human platelet-derived growth factor has also demonstrated improved healing.<sup>1</sup> However, dermatologists must continue to investigate prophylactic and therapeutic measures to end the run that chemical weapons have taken in wartime against the body's largest organ and its first line of defense.<sup>2</sup>

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1. Hurst CG, Petrali JP, Barillow DJ, et al. Vesicants. In: Lenhart MK, Tuorinsky SD, eds. *Medical Aspects of Chemical Warfare*. Washington, DC: Office of The Surgeon General at TMM Publications; 2008:259-311.

2. Vesicants (blister agents): mustard and nitrogen mustards. In: NATO, ed. *NATO Handbook on the Medical Aspects of NBC Defensive Operations AMedP-6(B)*. 1996: 301-316.

3. Warthin AS, Welter CV, Roos L, Herrmann GR. Treatment of dichlorethylsulphid (mustard gas) injuries. *JAMA*. 1918;71(14):1612.