Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

Case Report

A case of Tannerite® target mixture causing severe blast injury

Ryan E. Rebowe MD[a,*], Patrick Harbour BS[a], Jeffrey E. Carter MD[b], Joseph Andrew Molnar MD, PhD[a]

[a] Department of Plastic and Reconstructive Surgery Wake Forest University Baptist Medical Center, 1 Medical Center Blvd, Winston-Salem, NC, 27103, United States

[b] Department of Surgical Sciences Wake Forest University Baptist Medical Center, 1 Medical Center Blvd, Winston-Salem, NC, 27103, United States

ARTICLE INFO

Article history:
Received 28 December 2015
Accepted 18 January 2016

Keywords:
Blast injury
Tannerite
Binary explosive target

ABSTRACT

Tannerite® is a proprietary blend of an oxidizer, ammonium nitrate, and aluminum powder catalyst used to make homemade exploding targets. While it is currently approved for unrestricted sale in the United States, it can be used to form devices capable of inflicting major blast injury. We present here a case of close proximity exposure to detonation of the mixed Tannerite® blend. In our patient, the exposure lead to injuries typical of blast injury, such as tympanic membrane rupture, globe injury, and severe burns. We review here the sequelae of blast injuries that one must consider when treating a patient with close proximity exposure to Tannerite, with considerations unique to this product.

1. Introduction

Tannerite® is a product currently sold without restriction in the United States as a binary exploding target package. The components are stable separately, but when mixed become explosive when shot with the kinetic energy of a center fire rifle. This feature allows the operator of the rifle to visualize if their target is hit from long distances. According to its patent, the mixture is resistant to and will not explode when lower energy is applied, including heat energy (fire) or even rim fire cartridges. The resulting explosion is intended to be non-incendiary [1].

In addition to the multiple safeguards inherent in the design of the product, the manufacturer provides details about proper use of the material. As with all products, unintended consequences can occur when the product is misused. We present here a case of burn injury caused by the Tannerite® compound, with elements of the injury indicative of major blast injury.

2. Case presentation

A 41 year old man presented to our emergency department from a referring institution. Reportedly, the patient had placed the Tannerite® inside of a lit charcoal grill and discharged a firework into the binary explosive at point blank range. The kinetic energy generated by the firework was enough to cause the product to react, creating an explosive force against the surrounding charcoal, metal, and other surrounding objects.

* Corresponding author. Tel.: +1 336 716 4171.
E-mail addresses: rrebowe@wakehealth.edu, rrebowe1@gmail.com (R.E. Rebowe).

http://dx.doi.org/10.1016/j.burns.2016.01.020

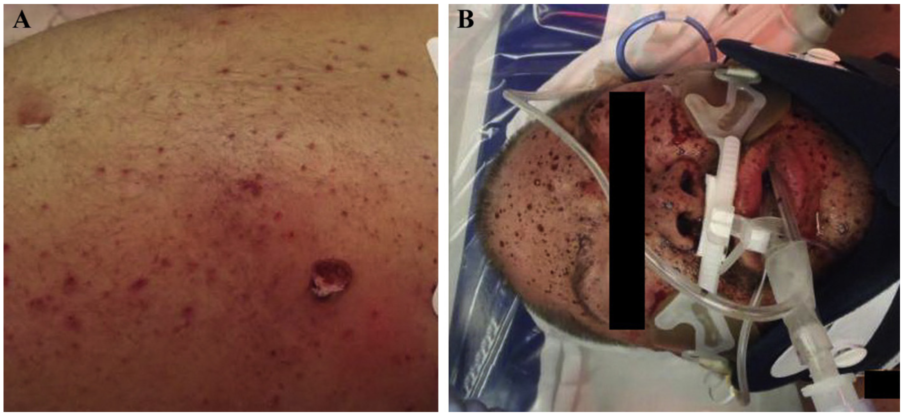

Fig. 1 – Multiple pinpoint lesions on the abdomen (A) and face (B) indicative of fragment injury. Many of these wounds ultimately underwent further debridement and closure due to foreign body reaction.

He was transferred intubated to our facility due to reported episodes of oxygen desaturation. On arrival he was approximately 3 h from post injury. Primary survey revealed a previously secured airway, adequate ventilation, and adequate IV access. His vital signs were stable with a Temperature of 98.0 °F, HR of 70 bpm, RR of 14, Oxygen Saturations of 100%, and BP of 137/90 mmHg. Secondary survey revealed significant bilateral ocular trauma, bilateral apparent hemotympanum, burn injuries and lacerations to his face, bilateral hands, and chest indicative of fragment injury. No foreign bodies were appreciated on initial survey.

The patient was admitted to our burn unit and extubated the same day without issue. His injuries following further assessment were as follows:

1. Superficial burns to his face, bilateral hands, forearms, and chest with evidence of pinpoint areas of full thickness skin defects and imbedded fragments (Fig. 1)
2. Bilateral absence of tympanic membranes with exposure of middle ear components (Fig. 2)
3. Thermal/Chemical burns of both eyes with large corneal abrasions and embedded foreign body; limbal ischemia evident in his left eye
4. Distal phalanx tuft fractures of the right hand thumb and index finger
5. Fracture of the proximal phalanx of the left thumb

The patient was managed four days in the burn unit for wound care, pain control, and occupational therapy. During that time his burn wounds and hand injuries were managed by the plastic surgery service with antibiotic lotion to his face and silver sulfadiazine to his hands and forearms. Due to the open fractures and multiple open wounds of his hands, the patient was also begun on Dial soap soaks. His tympanic membrane injuries and corneal abrasions were managed expectantly by ophthalmology and the otolaryngology department, respectively. As the patient did have significant disability of hearing, eyesight, and hand function, he underwent admission to an inpatient rehabilitation facility for eight days.

Subsequent management included operative treatment for open reduction and internal fixation of his left thumb proximal phalanx fracture and debridement of his wounds. (Fig. 3) His fracture was reduced through a dorsal midline incision and fixed with crossing 0.45 mm Kirschner wires. Small sand-like fragments was removed from multiple areas of his face and chest and his wounds were closed as appropriate. Following surgery his thumb and surgical sites healed without issue. Pins were removed one month after surgery and he achieved normal range of motion with proper occupational therapy.

His corneal abrasions were managed expectantly with artificial tears and antibiotic eye drops. At ten months these were noted to heal completely with minor refractive error. He was noted to have fragments embedded in his cornea, however

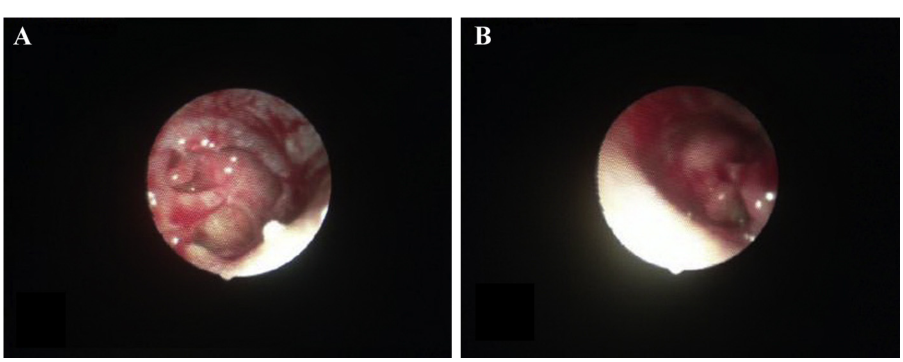

Fig. 2 – The patient had evidence of left (A) and right (B) tympanic membrane rupture. Ossicles are in direct view with direct visualization of the middle ear.

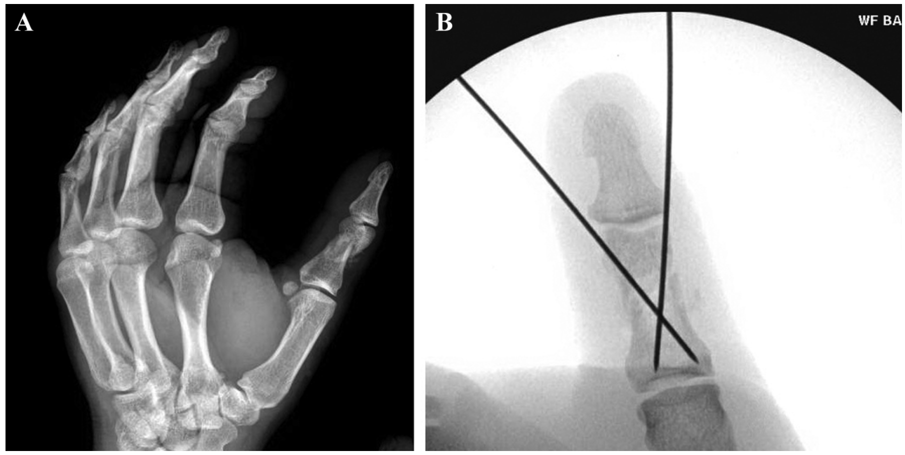

Fig. 3 – (A) The patient acquired an oblique fracture of the left thumb proximal phalanx. (B) Open reduction and internal fixation with 0.45 mm Kirschner wires.

retrieving this fragments would cause greater corneal injury. After three months of follow up with audiology and otolaryngology departments, his tympanic membrane injury was felt to result in likely permanent sensorineural hearing loss. He continues to follow with their Department and may be a candidate for reconstruction of his tympanic membranes in the near future.

3. Discussion

Tannerite® is currently sold without restriction in the United States. It is intended to be used as a target for center fire rifles, allowing the operator of the rifle to visualize if his or her target is hit from long distances. The explosive is sold as two separate components that are stable and noncombustible individually, hence the term binary explosive. This allows the materials to be sold without the federal regulations that normally accompany the sales of explosives and other hazardous materials. The two stable products create an explosive force when combined, with a catalyst added to an oxidizing agent. Its patent describes the oxidizing agent as mostly ammonium nitrate (~85%), with a small amount of ammonium perchlorate (~15%), while the catalyst is a mixture of mostly aluminum powder (~90%), with a small amount of zirconium hydride (~5%) and titanium sponge (~5%) [1].

To chemically combine the two reactants, the product must be impacted with a force carrying the appropriate kinetic energy. In the case of firearms this constitutes a round traveling at the speed of 2000 feet per second, which is typically only achievable by a center fire rifle. According to its patent, the mixture is resistant to lower energy catalysts and will not explode when such energy is applied, including heat energy or small caliber ammunition. Furthermore, the resulting explosion is intended to be non-incendiary. In addition to the multiple safeguards inherent in the design of the product, the manufacturer provides details about proper use of the material. These guidelines include standing an appropriate distance away from the target, lifting the target off of the ground, and not using more than two pounds of the mixture at a time.

As with all products, unintended consequences can occur when the product is misused. Consumers can purchase unlimited amounts of this material and use it to create large explosions in a thrill-seeking effort. These larger explosions are inherently more dangerous and more likely to cause injury than the intended use limit of two pounds. The material surrounding the Tannerite® explosion can also contribute to injury. Detonating the binary explosive mixture within metal or wooden structures, such as the metal grill used by our patient, could create fragments capable of causing penetrating injuries to those near the blast. The aluminum powder and other reagents used in the initial reaction could also create fragments if the operator is close enough to the target. Furthermore, detonation near or within an already burning fuel source could cause burn injuries from the flying debris even though the target is non-incendiary.

The distance between the product and the operator also plays a role in preventing injury. The explosive reaction can only be ignited with the kinetic energy from a round travelling 2000 feet per second. Therefore, a handgun, rim fire rifle, or other low caliber weapon will not initiate the reaction if the target is placed an appropriate distance away from the shooter. Similarly, traumatic impact from other non-explosive mechanisms, such as handheld tools, power tools, or heating elements will not carry enough energy to produce a reaction. However, any object with the appropriate kinetic energy will ignite the product. Utilizing other explosive mechanisms, such as common fireworks, or utilizing lower energy firearms at a closer distance could cause the binary explosive to react and result in injury.

Tannerite® is by definition a non-incendiary target, as all of the oxygen in the product is consumed by the initial reaction. However, the nature of the reaction does create a concern for blast injury if a large enough concentration of the substance is present. A blast, or explosion, results from an extremely rapid change in an explosive material from a liquid or solid phase to a gaseous phase. This rapid change in the state of matter causes a massive increase in local pressure, which dissipates outward from the source of the explosion in the form of a positive-pressure blast wave. The energy of this positive-pressure wave creates a vacuum that then exerts a negative pressure on the surrounding environment, causing a negative-pressure phase of the blast wave [2–7]. These forces combine to create tissue injury in a very specific way.

Blast injuries are generally divided into 4 or 5 subtypes, the first of which is direct tissue injury caused by the blast wave itself [7–9]. This is the subtype that is most unique to blast injuries. Direct tissue damage is caused by air that is compressed to such a degree that it simulates a solid object striking tissue [10]. Air-tissue interfaces, such as the lungs, gastrointestinal tract, and middle ear are most susceptible to this injury [4–6,11,12].

Damage to the auditory system can occur at lower pressures (35 kPa) while lung and GI damage typically occurs at higher pressures (75–100 kPa) [13,14]. Ruptured tympanic membranes, as the ones present in our patient, are the most common finding associated with blast injuries. The presence of ruptured TM's in the asymptomatic patient may indicate the presence of more serious, occult damage and should alert the treating surgeon to other possible pathology. Lung injury may result in pulmonary hemorrhage, contusion, air embolism, or direct barotrauma to the alveoli themselves. The gastrointestinal system can suffer serious trauma including perforation, intestinal wall hematoma, hemorrhage, ischemia, and contusion [4,7,15].

The remaining subtypes of blast injury are caused by the explosion, but not necessarily from the blast wave directly. Secondary injury is caused by debris acting as fragments from the explosion and injuring the victim. The types of fragments involved can complicate soft tissue injury management depending on what metals, bacteria, or other materials enter the soft tissue [16]. In our patient, significant fragments injury from the material surrounding the blast, such as the metal, wood, and charcoal of the grill, as well as unreacted products from the binary explosive resulted in non-healing wounds that underwent removal and scar revision.

Tertiary injury is usually blunt trauma sustained after contact with other objects when being thrown by the force of the blast itself. Quaternary injury is the injury that is caused by the explosion but does not fall into the first three categories. This type of injury could include burns, toxic exposures, or even psychological trauma. Some authors have described a quaternary blast injury that encompasses a generalized pro-inflammatory state in patients following explosive damage [2,4].

Here, we present a case of a young man who unfortunately suffered unintended consequences due to misuse of the Tannerite® explosive. He not only placed the target at an unsafe distance, but placed it inside material that would generate both sharp and incendiary debris. Several of the different types of blast injury were evident in our patient. His ruptured TM's are a classic finding that is sensitive for primary blast injury. Fragments from the initial explosion, characterized as secondary blast injury, resulted in non-healing wounds, revision surgery, and corneal injury. The phalanx injuries sustained were likely tertiary trauma, as a blast wave significant enough to induce bone fracture would likely have resulted in other major injuries that were not observed in this patient. The partial and full thickness burns he received are examples of some of the quaternary injuries that can be caused by explosions.

4. Conclusion

This is the first description of Tannerite® target mixture causing blast injury in the burn literature. Tannerite® is a benign compound when used appropriately, but it can be utilized in such a way that increases the risk of accidents and major injury. Any victim of an explosion utilizing the binary explosive compound should be suspected of having blast injury and may qualify for a higher level of monitoring such as the trauma or burn intensive care unit. It is the opinion of the authors that all trauma involving Tannerite® explosions should be treated with suspicion for possible blast injury.

REFERENCES

[1] Tanner DJ. Tannerite binary exploding targets, U.S.P.a.T. Office, Editor. United States.; 2003.
[2] DePalma RG, et al. Blast injuries. N Engl J Med 2005;352(13):1335–42.
[3] Stapczynski JS. Blast injuries. Ann Emerg Med 1982;11(12):687–94.
[4] Wolf SJ, et al. Blast injuries. Lancet 2009;374(9687):405–15.
[5] Stuhmiller J, Phillips Y, Richmond D. The Physics and Mechanisms of Primary Blast Injury, in Conventional Warfare: Ballistic, Blast, and Burn Injuries, O.o.T.S.G. Borden Institute, Editor.. Washington, DC.: United States Department of the Arm; 1991: 241–70.
[6] Phillips Y, Richmond D. Primary Blast Injury and Basic Research: A Brief History, in Conventional Warfare: Ballistic, Blast, and Burn Injuries, O.o.T.S.G. Borden Institute, Editor.. Washington, DC.: United States Department of the Army; 1991: 2221–40.
[7] Wightman JM, Gladish SL. Explosions and blast injuries. Ann Emerg Med 2001;37(6):664–78.
[8] Mellor SG. The pathogenesis of blast injury and its management. Br J Hosp Med 1988;39(6):536–9.
[9] Champion HR, Holcomb JB, Young LA. Injuries from explosions: physics, biophysics, pathology, and required research focus. J Trauma 2009;66(5):1468–77.
[10] Crabtree J. Terrorist homicide bombings: a primer for preparation. J Burn Care Res 2006;27(5):576–88.
[11] Avidan V, et al. Blast lung injury: clinical manifestations, treatment, and outcome. Am J Surg 2005;190(6):927–31.
[12] Sharpnack D, Johnson A, Phillips Y. The Pathology of Primary Blast Injury, in Conventional Warfare: Ballistic, Blast, and Burn Injuries, O.o.T.S.G. Borden Institute, Editor. Washington, DC: United States Department of the Army; 1991: 271–94.
[13] Arnold JL, et al. Mass-casualty, terrorist bombings: epidemiological outcomes, resource utilization, and time course of emergency needs (Part I). Prehosp Disaster Med 2003;18(3):220–34.
[14] Yang Z, et al. Biological effects of weak blast waves and safety limits for internal organ injury in the human body. J Trauma 1996;40(3 Suppl):S81–4.
[15] Garner J, Brett SJ. Mechanisms of injury by explosive devices. Anesthesiol Clin 2007;25(1):147–60.
[16] Sheean AJ, Tintle SM, Rhee PC. Soft tissue and wound management of blast injuries. Curr Rev Musculoskelet Med 2015;8(3):265–71.