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Nation's Future: Preparedness for Burn Victims

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Executive Summary

Natural and manmade disasters have occurred throughout the decades, within the United States and around the globe. Increased incidence and awareness of terrorist attacks have caused the US to re-evaluate its safety and preparedness efforts to prevent such events from happening and to develop an adequate response plan if such unfortunate events do occur. Therefore, the purpose of this research is to (1) review and discuss the American Burn Association's (ABA) paradigm for emergency planning in burn disasters, (2) give recommendation about the National Response Framework (NRF) guidelines on "all hazards" response as they pertains to burns, and (3) give recommendations on how the US can maintain an ample supply of allograft tissue for emergency situations that result in burn victims.

A literature review was completed, and a best practices approach for the above issues was created. Recommendations were given to strengthen both ABA's response plane and the NRF guidelines for burn casualties. Also, opportunities to achieve better outcomes for burn victims by promoting and starting an allograft tissue reserve were recommended. The ABA's emergency response plan for events that produce mass burn casualties was reviewed. Primary and secondary triaging of burn victims to burn centers is the model used for this organization, yet the ABA's plan was not congruent with other federal and regional response plans. Differences in these plans centered around triage protocols for treatment on scene as opposed to triage and evacuation to burn centers. Recommendations were given to improve the ABA's emergency response plan by incorporating other plans and maintaining congruency to accommodate local responses. Furthermore, recommendations for the NRF were constructed by using criteria from the ABA. The NRF provides guidelines for all aspects of government including local, tribal, state, and federal levels by describing how to respond to emergencies for all hazards. Even

though this framework provides incident command structure, organization, and alternate resources and organizations, the framework only depicts a broad representation of response actions and does not give detail or awareness to more specific or critical circumstances. If emphasis from the NRF were placed on both local and state awareness of the complexities of mass burn management in emergency situations, better outcomes would be produced. By using the ABA's response model and guidance from the NRF, regions could create efficient response plans with resources already sustained by their area if federal assistance were unable to reach the emergency in time.

The US simply does not have enough allograft tissue available to respond to an emergent event involving mass burn casualties. Although autografts are the preferred method of grafting, other temporary and permanent skin alternatives were reviewed for advantages and disadvantages. Skin on skin is the graft of choice, whether the procedure is an autograft (the person's own skin) or allograft (skin from a cadaver); as this has been shown to produce the best results versus other alternatives. When burned individuals are unable to provide autografts due to the severity of their burns, cadaveric allograft skin can be used to decrease pain, prevent infection, promote skin growth, and act as a temporary barrier. Proper cryopreservation of allograft tissues preserves these tissues up to five years, with no decrease in viability. Recommendations have been given for the United States Food and Drug Administration (FDA) to regulate a strategic stock of cryopreserved allografts for emergency situations, and for the American Association of Tissue Banking (AATB) to establish and maintain this allograft tissue reserve. Achieving both of these recommendations would allow monitoring inventory using strict storage guidelines and circulating inventory to ensure use before its five year expiration. Further research needs to be completed on these issues to provide additional support and

significance. If the recommendations provided were implemented, our nation could save more lives in disasters involving mass burn injuries.

Introduction

After the terrorist attack on September 11th, 2001, the United States and its citizens have become more aware of how terrorist activity can have a deeply personal and detrimental effect on the health and livelihood of a nation. With increasing awareness of possible additional attacks, the nation's response and recovery systems have been identified as critical components for preventing more casualties and saving lives in the event of disaster or attack. Adequate planning is required along with preparation and anticipation of such horrendous incidents to ensure public health safety. Burn injuries may comprise a significant portion of the health threat from future attacks, and a systematic approach is required to be adequately prepared to manage these events.

More than 300,000 people die from fire related injuries each year (Peck, Molnar, & Swart, 2009). Skin allograft, the use of skin grafts from cadaveric tissue donation, is the defining link for the survival of burn victims. Cadaveric skin acts as a barrier for keeping out infection, decreasing pain, and reducing dehydration for burn patients (Community Tissue Services, 2009). However, in a disaster, the demand of burn patients can easily exceed tissue supply resulting in increased morbidity and mortality. A national emergency plan for dealing with mass burn victims is necessary to address this potential threat to the public health.

Purpose

The purpose of this research is to: 1) review American Burn Association's (ABA) emergency response plan criteria for burn casualties and use them as a foundation to 2) provide recommendations and critiques for the proposed response to burn victims in the "all hazards approach" of the National Response Framework (NRF), and 3) provide recommendations on how the US can ensure an adequate supply of allograft tissues, particularly skin for burn victims

in disasters. Planning and preparation for burn scenarios in the future will help save lives by meeting the anticipated demand for allograft tissues. Not only will this plan help to improve the lives of those affected, but it will also serve as a model which other nations can emulate.

Review of Literature

Tissue Banking

Allograft tissues can help save lives and access to these resources through tissue banks is vital (Leon-Villapalos, Eldardiri, & Dziewulski, 2010). Tissue banking in the US is relatively new; however, the use of skin graft transplantation can be dated back to ancient Indian texts from 3000-2500 BC (Herman, 2002). The United States Navy Tissue Bank was established in 1949 as our nation's first tissue bank, and this organization also founded the American Association of Tissue Banking (AATB) in 1976 to ensure safety guidelines for the increasing demand of allograft tissues (AATB, 2010). The AATB is the only national, non-profit organization for tissue banking in the US and is the only national organization for accreditation of tissue banks within the United States (US) and Canada. The AATB standards and guidelines for tissue banking are recognized regionally and nationally and serve as a template for similar operations internationally. For example, in 1998 Singapore initiated skin banking operations and adopted the AATB guidelines and standards for donor retrieval (Chua, Song, Chai, Chan, & Tan, 2004). From 1998 to 2003, the Singaporean skin bank was able to provide allograft skin for 51 burn patients; however, only 35 local donors supplied skin. The rest of the allograft supply came from accredited tissue banks overseas. Chua and colleagues (2004) eluded to the fact that without support and supplies from international tissue banks, the treatment for those burn patients would have been interrupted causing detrimental effects. Despite the AATB's position as a worldwide

leader in tissue banking, its ability to respond to a disaster is still dependant on an adequate supply of allograft skin.

If circumstances were reversed, the lack of tissue banks and allograft tissue reserve in Singapore as noted by Chua and colleagues (2004) would inhibit Singapore's ability to help supply the demands of other countries in need of tissue grafts in emergencies. Despite a program of international mutual support, all nations should individually implement a reserve of allograft tissues to have on hand in the event that international aid and supply are not readily available. The recognition of and significance for practicing skin banking and starting an allograft skin reserve for burn patients within each nation are demonstrated in Singapore's example.

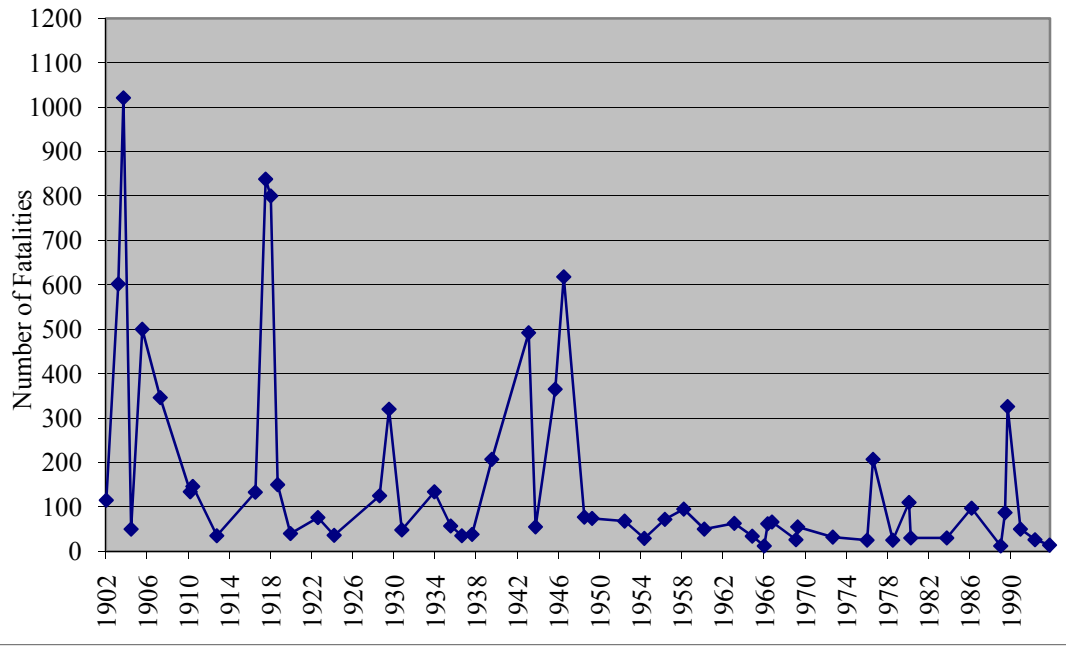
Regulations

Federal and state regulations provide standards to preserve the safety of skin grafts and to prevent the spread of disease. The Center for Biologics Evaluation and Research (CBER), which is a division of the US Food and Drug Administration (FDA), regulates all donor human cells, tissues, cellular, and tissue based products (HCT/P) that may be transferred to another human recipient, either by transplantation, implantation, or infusion. CBER regulates donor skin but not human organ transplantation such as kidney, heart, etc. (FDA, 2010). Federal law requires tissue banks to screen and test donors for communicable disease, to register any HCT/P supply with the FDA, and to maintain good tissue practices (FDA, 2010). In addition to the FDA's guidelines, individual state regulations and AATB credentialing standards serve as the basis for enforcing safe practices for skin allografts in order to decrease the chances for infection, promote wound healing, and decrease fluid or heat loss from burn victims (Leon-Villapalos et al., 2010).

Burn Disasters

Fortunately, for more than a decade the US has not experienced any significant burn disasters producing multiple victims in need of allograft tissue to save lives. However, the resulting complacency is worrisome. Barillo and Wolf (2006) investigated significant 20th century US fires and burn disasters resulting in mass casualties and burn injuries and identified 73 recorded events from 1900 to 2000 that incurred fatalities and injuries (see Appendix A). This study concluded that there were far more casualties resulting from burn disasters in the first half of the century than the second half as displayed in Figure 1[1]. The decrease in casualties

Figure 1. Deaths from fire or burn disasters, 1900 to 2000.



resulting from a burn disaster may be explained by better housing codes, fire codes, fire safety, and improved techniques for housing in last half of the 20th century (Barillo & Wolf, 2006). However, treatment of fewer burned victims than anticipated is partially a result of a higher than

[1]From "Planning for Burn Disasters: Lessons Learned From One Hundred Years of History," by D. J. Barillo and S. Wolf, 2006. *Journal of Burn Care & Research*, 27, p. 626. Copyright 2006 by the American Burn Association.

expected mortality rate among burn victims in disasters (Barillo & Wolf, 2006). Even though casualty trends for burn disasters are decreasing, well prepared and properly executed plans with adequate life saving supplies are needed.

The potential for burn disasters is a global concern. McGregor (2004) described a need for a national plan for burn disasters in the UK and Scotland and concluded that incident disaster plans for hospitals are not specific enough to account for burn victims who will consume or exhaust burn centers, beds, and supplies. Including events from around the globe, McGregor (2004) listed major burn disasters from 1973 through 1988 (Table 1). The lack of planning and resources nationally and internationally for massive numbers of burn victims indicates that the public may be unprepared for such disasters.

Table 1. Major Burn Disasters Between 1973 and 1988

Outdoor Disasters	
1973 Kampala (Africa)	Petrol fire in a market
1978 L.AIfaques (Spain)	Campsite fire
1981 Bangalore (India)	Fire at a circus
1985 Bradford (England)	Fire in a football stadium
1988 Ramstein (Germany)	Aircraft crash at an air show
Indoor Disasters	
1973 Summerland (England)	Fire in leisure complex
1981 Dublin (Ireland)	Fire in a discotheque
1984 Cardowan (Scotland)	Coal mine explosion
1985 Manchester (England)	Aircraft crash and fire
1988 London (England)	Fire in the underground
1988 Aberdeen (Scotland)	Piper alpha fire on oil platform

Note. From "Major Burn Disasters: Lessons to Be Learned from Previous Incidents and a Need for a National Plan," by J. C. McGregor, 2004, *The Surgeon: Journal of The Royal Colleges Of Surgeons Of Edinburgh And Ireland,* 2, p. 250. Copyright 2004 by The Surgeon.

Wound Care

Preparation for incidents involving multiple burn victims must include a plan for the most effective treatment of such injuries. When caring for an injury caused by a burn, skin-on-skin

grafts, or allografts, are the most desirable as opposed to alternative grafts. Wound care for burns is a very time-consuming, multifaceted process that demands involvement from all facets of the health care team. Retrospective studies including Tompkins and colleagues (1989) showed significant improvement when adult patients presenting with burns to a total body surface area (TBSA) of 70 percent and above were treated with excision of eschar tissue and closure of wounds with artificial tissues. Increased use of this method of treatment is credited with improving survival rates from 24 percent of adults admitted to the Massachusetts General Hospital Adult Burn Unit in 1974-1975 to 48 percent in 1984-1986 (Tompkins et al., 1989). More recently, a study by Chua and colleagues (2004), compared an experimental group of patients who received early debridement and skin allografts placed within 72 hours from injury and a control group of patients who did not have debridement or transplantation within 72 hours of the initial injury (Chua et al., 2004). Mortality rate in the study group was only 16 percent as compared with 45 percent in the control group. This study shows a 29 percent decrease in mortality in the study group who received excision within 72 hours of burn trauma. Length of hospital stay also decreased by about 10 days in the study group (48.3 days) versus the control group (58.5 days) (Chua et al., 2004).

Burn wounds that reach down to the deep dermis or further, also called deep dermal burns or full thickness burns, require more specialized care due to their complex recovery versus superficial or partial thickness burns. Deep partial and full thickness burns need debridement or excision of dead and inflamed tissue which would otherwise impede healing or cause possible infection of healthy tissue (Cameron, Ruzehaji, & Cowin, 2010). After debridement is completed, the burn victim will undergo several more surgeries to graft allograft tissue (cadaveric skin), xenograft tissue (normally pigskin), or some other genetically engineered tissue

covering. These grafts will act as a barrier to keep out infection and increase fluid retention (Cameron et al., 2010). Understanding the phases of wound healing provides perspective on how managing wound care is critical to ensuring optimal outcome for burn victims as shown in Figure 2.[2]

Figure 2. Phases of wound healing, major types of cells involved in each phase, and selected specific event.

Time	Phases	Main Cell Types	Specific Events
	Coagulation Fibrin plug formation, release of growth factors, cytokines, hypoxia	Platelets	Platelet aggregation and release of fibrinogen fragments and other proinflammatory mediators
Hours		Neutrophils, monocytes	
	Inflammation Cell recruitement and chemotaxis, wound debridement	Macrophages	Selectins slow down blood cells and binding to integrins diapedisis
Days			Hemidesmosome breakdown keratiocyte migration
	Migration/proliferation Epidermal resurfacing, fibroplasia, angiogenisis, ECM desposition, contraction	Keratinocytes, fibroblasts, endothelial cells	Cross-talk between MMPs, integrins, cells, cytokines, cell migration, ECM production
		Myofibroblasts	
Weeks to Months	**Remodelling** Scar formation and revision, ECM degradation, further contraction and tensile strength		Phenotypic switch to myofibroblasts from fibroblasts

Defining the Problem

Proper management of wound care is critical in an effective response framework for disaster response, such as to a terrorist attack. Since the attacks of September 11th, suspicion of

[2] From "Burn Wound Management: A Surgical Perspective," by A. M. Cameron, N. Ruzehaji, and A. J. Cowin, 2010, *Wound Practice and Management,* 18, p. 36. Copyright by Wound Practice and Management.

terrorist attacks has remained high. Terrorist attacks would likely produce a significant number of burn casualties, since such attacks often include accessible weaponry like highly flammable fertilizer for bombs versus complex weaponry (Cancio & Pruitt, 2005). Many of the recent burn disasters worldwide, as addressed by Cancio & Pruitt (2005), were caused by bombs from terrorists (Table 2).

Table 2. Selected recent burn mass casualty disasters.

Date	References	Location	Cause	Number of injured survivors	Number of on-scene dead
1970	(6)	Osaka, Japan	Natural gas pipeline	428	79
1976	(67)	Nakivubo, Kampala, Uganda	Gasoline tanker truck	71	11
1977	(68,69)	Southgate, Kentucky, USA	Supper club fire ('Beverly Hills')	5	160
1978	(7)	Los Alfaques, Spain	Liquid propylene gas	140	102
1980	(8)	Las Vegas, Nevada, USA	Hotel fire ('MGM Grand')	726	84
1981	(70,71)	Dublin, Ireland	Nightclub fire ('Stardust')	44	48
1981	(72)	Bangalore, India	Circus fire	169	92
1982	(73)	Cardowan, UK	Coal mine explosion	40	0
1984	(9)	San Juanico, Mexico	Liquid propane gas	723	300
1985	(10)	Bradford City, UK	Football stadium fire	256	52
1985	(74)	Manchester, UK	Aeroplane fire	79	52
1988	(11)	Piper Alpha platform, North Sea, UK	Oil rig fire	25	167
1988	(41)	Ramstein, Germany	Aeroplane crash	400	45
1989	(13)	Bashkiria, Russia	Natural gas pipeline	800	400
1990	(75)	Va¨dero¨arna, Sweden	Fire on ferry boat (Scandinavian Star)	30	158
1994	(14,76)	Pope Air Force Base, N. Carolina, USA	Aeroplane crash	119	11
1998	(16)	Gothenburg, Sweden	Discotheque fire	213	60
2001	(17)	Volendam, The Netherlands	Cafe´ fire	245	4
2001	(1,21,77)	New York City, USA	Aeroplane attacks (World Trade Center)	790	271 3†
2002	(2,23,24)	Bali, Indonesia	Nightclub bombings	155 (78)	202 ‡ (79)
2003	(25)	West Warwick, Rhode Island, USA	Nightclub fire ('Station')	215	96

*Where available, this number refers to casualties arriving alive at hospitals or other medical treatment facilities, and receiving either inpatient or outpatient care; includes patients with burns, inhalation injury, and other injuries. †Where available, this number refers to casualties dead at the scene. ‡Final estimate of all deaths caused by the event.

Note. From "Management of Mass CasualtyCasualtyBurn Disasters," L. C. Cancio and B. A. Pruitt, 2005, *International Journal of Disaster Medicine,* 000, p. 2. Copyright 2005 by Taylor & Frances Group, Ltd.

The AATB has collaborated with our nation's emergency response systems during a disaster to communicate available supply. During the attacks of September 11th, 2001, the AATB Emergency Preparedness Committee sent fax bulletins out to all national accredited tissue banks asking them how much fresh or frozen skin they could send out and contribute to respond to the demand that this disaster produced. Collectively, about 20 tissue banks responded to the fax bulletins, and from these responses the AATB estimated a supply of about 1500 square feet of cadaveric skin available for the incident (AATB, n.d.). Fortunately, the ABA and other national centers for response relief of resources had a sufficient skin supply to meet the demands generated by the disaster. Shortly after the destruction of the World Trade Centers, the AATB Skin council held a teleconference to review the current situation and to discuss possible emergency response framework for when similar disasters might happen in the future. During the teleconference, an AATB Emergency Preparedness Task Force was created, and contacts were initiated with the Department of Defense and Office of Emergency Preparedness for the Department of Health and Human Services (DHHS). Another outcome of the teleconference was to set up a way to monitor the national supply of skin tissues by instructing all accredited distribution banks to send weekly reports of inventory (AATB, n.d.). These efforts by the AATB and the resulting collaborations are significant steps to the initiating a national strategic reserve of skin in the US to help decrease morbidity and mortality in burn emergencies.

Logistically being prepared for disasters can be challenging and requires attention from all parties involved. At the AATB's 33rd Annual Meeting held on September 8, 2008, in Chicago, Illinois, the Association's Emergency Preparedness Task Force defined itself as being prepared to allocate services by monitoring the nation's supply of skin tissue for both local and national disasters. This task force periodically performs surveys to monitor skin supply available

for distribution and noted that in 2006, 2,100 square feet were distributed, compared to 6,852 square feet in 2008 (AATB, 2008). According to the data produced from their monitoring of distributed skin, the US network of accredited tissue banks has increased the exchange of available skin supply from 2001 to 2008.

The AATB's Emergency Task Force has improved the nation's organization and response in an event of a disaster producing mass burn casualties, but there is still room for concern and improvement. What if there had been a larger number of surviving burn victims on September 11th, 2001? What other measures would the US have taken to get supplies that would meet the demand? Would it be possible to get assistance from other nations in a timely manner when many aspects of transportation or communication methods have been cut off? When examined, these issues can be quite overwhelming and difficult to resolve. These different aspects will be examined to justify why it is vital for the US to be prepared for all disparate circumstances.

The US deals with many burn victims each year due to accidents around the home, work place, or other various areas. An estimated 450,000 individuals with burns received treatment in the US over a ten year period from 2001 to 2010; every year about 3,500 of these patients do not survive the burn injury even after attempted treatment (American Burn Association [ABA], 2011). Because many of these burn victims could have pursued treatment outside of hospitals, such as through a private physician's office or an outpatient clinic, it is difficult to predict exactly how many individuals received burn care. Accordingly, the American Burn Association's (ABA) estimate may well be skewed. The ABA (2011) also estimated that 55 percent of the 45,000 burn injuries per year were admitted to burn centers or hospitals that have a specialized burn care unit versus admission to an acute care hospital for treatment. Additionally,

the ABA (2011) also commented on the increasing admission to burn centers in recent years due to the increasing knowledge of the complexity and specialization needed for these individuals that acute US hospitals are unable provide.

Burn scenario

Defining the gap between the supply and demand of distributed skin allografts when a burn disaster is present can be problematic. As previously stated, the AATB's emergency preparedness task force periodically monitors the supply of distributed skin tissues from US banks, but this may not always be completely accurate if not all of the contributing banks respond. Also, the amount of skin supply is changing throughout the years due to either increasing or decreasing donor recovery even though the amount of distributed cadaveric skin in the US has increased throughout the years. This issue seems to be problematic, not only nationally but also globally due to lack of donors, money, recovery sites, and trained staff personnel.

The US Department of Homeland Security (DHS) has projected future threat scenarios and has provided an appropriate emergency response plan for each scenario. In one of the scenarios, the DHS estimated the damages expected from a suicide bomber and explosive devices set off in a crowded urban location such as in or around a sports arena. Damages in these urban locations could include the surrounding areas, such as vehicle bombs set off in the events parking lots or suicide bombers inhibiting transportation for individuals to escape from the incident, making this occurrence a multifaceted attack (DHS, 2005). The DHS (2005) also comments that bombers could potentially bomb hospital lobbies near the initial incident causing further delays and injuries. Using the projected casualties from this scenario, the DHS estimated 450 hospitalizations per event (Table 3) (DHS, 2005). Incident locations for possible detonation

are shown in Table 4 and include highly populated urban areas such as a downtown city neighborhood, sports event, or public transportation like subways. For an incident in a public transportation area, such as a subway, the DHS estimated that there would be 8 fatalities and about 150 serious injuries as indicated in Table 4. The DHS does not specify whether or not those 150 injuries include extensive burns requiring grafts; however, DHS does conclude that this victim count would include injuries from the "walking wounded," to multiple system traumas and burns. In 2001 the AATB's Emergency Preparedness Committee communicated that US skin banks collectively had about 1,500 square feet of cadaveric allografts available. During that time there were more tissue banks that were processing skin than there are today (D. Wilson, personal communication, June 6, 2011). The largest supplier of distributed skin is Community Tissue Services (CTS) (2009), and even when CTS is joined with other banks that distribute skin, the US would only have enough skin for an additional 5 to 10 patients who need grafts during an emergency (D. Wilson, personal communication, June 6, 2011). Daily requirement for allografts already exceed the 1,500 square feet due to current daily use from routine burn patients that need all available harvested tissues (D. Wilson, personal communication, June 6, 2011). If an adult has full thickness or deep thermal burns that consist of 30 percent or more of their TBSA, that adult will not have enough of their own skin to graft the wounds; therefore allografts are needed to meet this need (Schlatter, 2011). Kagan and colleagues (2009) described a case study where a total of about 15 square feet of allograft tissue was applied in multiple surgeries on a patient who sustained third degree burns over 75 percent of their TBSA. Therefore, considering the projected 150 injured individuals from a terrorist's bombing attempt, the demand for the event would exceed the 1500 square feet of donor skin in the US supply, signifying the importance of establishing a national reserve of allograft tissue.

Table 3. Scenario 12: Explosives Attack – Bombing Using Improvised Explosive Devices

Casualties	Approximately 100 fatalities; 450 hospitalizations
Infrastructure Damage	Structures affected by blast and fire
Evacuations/Displaced Persons	Evacuation of immediate area around each explosion results in approximately 5,000 people seeking shelter in safe areas
Contamination	None
Economic Impact	Millions of dollars
Potential for Multiple Events	Yes
Recovery Timeline	Weeks to months

Note. From "National Planning Scenarios: Executive Summaries," by DHS, 2005, p. 12-1.

Table 4. Summary of fatalities and serious injuries as a result of the bombings

Incident or Location	Fatalities	Serious Injuries
Initial suicide bombings	8	150
Large Vehicle Bomb	35	200
Parking facility car bomb	7	40
Public Transportation Concourse (subway)	8	50
Hospital ER	8	40

Note. From "National Planning Scenarios: Executive Summaries," by DHS, 2005, p. 12-3.

To further define the gap, an even worse scenario noted by Aghababian and colleagues (2007) will be reviewed. The Basic Disaster Life Support (BDLS) Provider Manual (Aghababian et al., 2007) describes what would happen in an event of a nuclear weapon detonation. A fireball 10,000 times hotter than the nuclear device itself will be released from the explosion after detonation has occurred and will result in the majority of burn injuries. The BDLS manual projects that the mass amounts of burn injuries incurred during this incident will cause logistical medical issues (Aghababian et al., 2007). If nuclear detonation occurs in an urban area, the BDLS manual estimates several hundred thousand serious burn victims will be generated (Aghababian et al., 2007). The breakdown of injuries from a nuclear detonation were given and included: 15-20 percent burns; 5 percent wounds and burns; 20 percent burns, wounds, and irradiation; and 40 percent burns and irradiation (Aghababian et al., 2007). The victims from

just one medium sized nuclear weapon are estimated to fill every burn bed in the Eastern US (Aghababian et al., 2007). Initial blasts (13 percent), infection (45 percent), organ system failure (41 percent), and iatrogenic intervention (1 percent) are all expected to contribute to burn deaths in the event of a weapon of mass destruction (Aghababian et al., 2007). Due to delays in arrivals of emergency personal, state aid, and federal assistance, the BDLS Provider Manual concludes that most severe and moderately burned victims would perish before response arrived since too much time would elapse (Aghababian et al., 2007). A nuclear detonation incident defines a worst case scenario for burn casualties. Not only would there be an inadequate supply of allografts for several hundred thousands of serious burn victims, but also there are not enough burn centers or beds to accommodate this mass casualty incident.

Methods

Current peer reviewed articles addressing burn disasters, tissue banking, skin grafting, wound management for burns, and prevention and planning for such disasters were obtained via databases including CINAHL, and PubMed. Websites of other national organizations including ABA, FDA, AATB, National Burn Repository (NBR), and Community Tissue Services (CTS) were investigated for further data on skin banking, management, and operations. Also, the Federal Emergency Management Agency (FEMA) was reviewed for specific criteria relating to burn disasters. The medical librarian from Wright State University helped to find relevant articles within the databases and helped to assist in further research on the defined purpose. Key words to help facilitate data retrieval included but were not limited to: burns, burn disasters, tissue, tissue banks, skin, skin reserve, cadaveric skin, allografts, disaster planning, mass burn casualty, tissue donation, burn care, burn center, disaster training, emergency preparedness, and burn disaster response. Research was not limited to findings in the US, and emergency readiness

plans and research from other countries were used as well. Since tissue banking is relatively new to the US and even more so in other countries, and since burn disaster preparedness has not been heavily analyzed, research from other countries was utilized to get a better perspective on international supply and demand issues. Search engines such as Google were used for research to find secondary sources for further support. Additionally, national websites were used including: AATB survey results, FEMA, National Incident Management System (NIMS), skin reserve, cryogenics, FDA, and NBR. Furthermore, through contacts with CTS, and contact with the AATB president, further research and articles were obtained. Articles used were generally limited to publications from the last ten years. However, a few sources used cited data from older events. The process for selecting articles was driven by the goal of finding more information about the three primary purposes of this paper as stated in the introduction, that is, articles pertaining to: the ABA burn response plan, NRF medical response to burns, and research that support and show awareness for the need of an allograft skin reserve. Military and other international articles on emergency response plans for burns disasters were analyzed collectively to give insight on existing emergency response plans in the US.

Results

American Burn Association Emergency Response

The American Burn Association (ABA) (2006) estimates that about 20 to 30 percent of victims from general traumatic events will be in need of burn care treatment. Therefore the ABA, along with other state and federal resources has made an effort to put forth a preparedness plan for mass burn casualties. Only 43 out of 128 burn centers in the US are verified by the ABA and American College of Surgeons (ACS) which can present challenges in triaging (ABA, 2006). The ABA has put forth primary and secondary triaging policies into their emergency

preparedness plan. Primary triaging begins at the scene of the incident or in the emergency department. Burn victims should be transferred to the nearest burn center within 24 hours of incident (Veenema, 2007). Partial thickness burns that cover 10 percent of a victims TBSA, inhalation insult, third degree burns, or burns that cover the face, hands or feet are just some of the criteria for transporting victims to burn centers (ABA, 2006). Each state or local disaster plan is required to incorporate burn centers into plans under federal legislations (Veenema, 2007). Secondary triaging includes transferring of burn casualties from one burn center to another if that burn center reaches capacity by transfer agreements (Veenema, 2007). This tiered response plan, depending on the severity and involvement will include: state and local response, National Disaster Medical Systems (NDMS), Disaster Medical Assistance Teams (DMAT), Burn Specialty Teams (BST), and military support including Army Special Medical Augmentation Response Teams (SMARTs) (Veenema, 2007). Furthermore, the ABA, HHS, DHS, NDMS, and the US Institute of Surgical Research are working on "action items" to improve preparedness for burn casualties including discussion on a reserve for burn supplies in the National Strategic Stockpile (Veenema, 2007). The ABA recognizes the importance of preparedness for burn victims and the ongoing acknowledgement for further advancement in care for such individuals.

National Response Framework

The US Department of Homeland Security (DHS) has created national guidelines, which have been approved by the President for use in emergency situations. The National Response Framework (NRF) uses an "all-hazard approach" and incorporates the collaboration of federal organizations, nongovernmental organizations (NGO), and private sectors (DHS, 2008). The NRF demonstrates levels of effective response: 1) prepare, 2) respond, and 3) recover (DHS, 2008). Each level of emergency response provides general guidelines and is represented as the

framework's core purpose. Preparedness consists of planning, organizing, providing training and equipment, practicing exercises, and lastly evaluation and improvement (DHS, 2008). The respond process incorporates situational awareness, deployment of resources and capabilities, coordination of response actions, and demobilization (DHS, 2008). The last level of effective response is recovery and requires coordination with multiple resources and will differ for each incident depending on damages and the time involved in restoration (DHS, 2008). The Incident Command Structure (Appendix B) is used by local responders to effectively execute their responses within the recommended framework (DHS, 2008). The NRF provides best practices in managing disasters of all kinds.

During a burn disaster, the NRF provides communities with recommendations on how to respond in an emergency. Specifically, the NRF established the Emergency Support Function (ESF) # 4, which is the Firefighting Annex, detects and suppresses not only wildlife fires but also fires produced from incidents in rural and urban areas (FEMA, 2004). Priorities for ESF #4 include policies to protect the public, firefighters, and property (FEMA, 2004). This function would be federally deployed if regions or communities could not control fire incidents preventing further damages or lives lost. The ESF #8, which is the Public Health and Medical Services Annex, and when implemented would bring federal assistance to these regions including medical care personal and medical equipment and would provide patient care for burn casualties (Federal Emergency Management Agency [FEMA], 2008). This ESF accommodates emergencies in need of assistance with direction, communication, and transportation efforts which would be relevant during burn victim care (FEMA, 2008). ESF #8 also can provide biological products for immediate medical response and help direct mass fatality management. ESF #8 is also in charge of notifying other partner organizations for assistance of logistics

matters dealing with tissues (FEMA, 2008). The NRF's ESF #8 if deployed in a disaster would facilitate response to burn casualties in emergencies, consequently saving more lives.

American Association of Blood Banks

The American Association of Blood Banks (AABB) response plan model for emergencies and disasters was reviewed. Established in 2002, the AABB Interorganizational Task Force on Domestic Disasters and Acts of Terrorism keeps track of the nation's blood product inventories, assesses the need for collection or transportation if a disaster happens, and provides a clear message to the public regarding the blood supply need (AABB, 2011). This task force incorporates several different entities including US blood services, government agencies, and commercial entities that work together to ensure an adequate supply of blood products is available when an emergency arises (AABB, 2011). The AABB's (2011) emergency response plan consists of the following four steps: (1) The affected blood collector assesses the need and projected need for blood products; (2) this center then contacts the AABB; (3) the AABB contacts the Interorganizational Task Force which then sends a message to all registered blood donors in that area or blood community, and coordinates transportation of blood products to the affected area; and (4) recommended implementation is advised by the task force including notifying the Department of Health and Human Services (HHS) (Appendix C). Supported by the HHS, one way to maintain an adequate inventory is the development of "stoplight" by America's Blood Centers (AABB, 2011). This tracking tool can be accessed on the web by anyone to view daily supply of blood products from America's Blood Centers' blood banks. Red blood cells (RBCs) can be stored up to 42 days in refrigeration, or 10 years if frozen. Platelets can kept at room temperature for a maximum of 5 days, and fresh frozen plasma can be kept up to one year in a frozen state (AABB, 2011). Blood products are regulated by the FDA, and transportation of

these essential lifesaving products during emergencies can be challenging as improper temperature regulation can make these products unsafe. The AABB's emergency response model and task force provides a framework for emergency preparedness for blood products and contributes guidance for establishing a tissue reserve.

Cryopreservation

Cryopreservation of cadaveric skin is one way to preserve tissues. Fresh allografts (only subjected to refrigeration) can last up to about two weeks; however, there is difficulty in maintaining continuous or amply supple beyond two weeks signifying the need for alternate preservation methods such as cryopreservation (Kagan, Robb, & Plessinger, 2005). Kagan and colleagues (2005) propose that further skin banks worldwide will need to cryopreserve allografts to meet the increasing demand and that more research in cryopreservation will need to be conducted. Furthermore, allograft viability and adherence to the recipient decrease over time but can last up to several weeks if stored at refrigeration of 4 degrees Celsius and in an appropriate medium (Ben-Basset et al., 2001). According to AATB standards, skin preserved by programmed freezing at a rate of 1 degree Celsius per minutes will help to maintain the tissues' viability (Ben-Basset et al., 2001). Ben-Basset and colleagues (2001) explain that tissue banks worldwide preserve and store their tissues differently. Several banks in Eastern Europe and the Netherlands use the glycerolization method to preserve skin. The Israel National Skin Bank (INSB) uses cryopreservation as a method to preserve allografts, which consists of programmed freezing at a controlled rate with subsequent storage in liquid nitrogen (Ben-Basset et al., 2001). Allografts cryopreserved for five years did not show a significant viability decrease compared to fresh allografts; however crypopreserved allografts did show a significant decrease in viability after five years (Atiyeh, Hayek, & Gunn, 2005; Ben-Basset et al, 2001). Preservation and

storage of allografts is an essential component of a system designed to optimize the survival of burn victims in a disaster.

Human Allografts

When full thickness burns cover 30 percent or more of a victim's TBSA, there may not be adequate or attainable skin present for autografts; therefore, cadaveric skin or allografts would be the next choice, or "gold standard" for temporary wound covering in these circumstances (Kagan et al., 2005). For shallow and deep partial thickness facial burns, which occur in over 50 percent of large burns, cadaveric allograft skin is superior to the standard of care for facial burns treatment using silversulfadiazine ointment (Horch, Jeschke, Spilker, Herndon, & Kopp, 2005). Allografts provide several life saving functions (Table 5). This temporary covering provides a barrier, re-vascularizes, and will last up to 3 to 4 weeks until rejected by the recipient (Demling, Orgill, & DeSanti, 2004). Some disadvantages noted are: allografts have the potential to transmit diseases; they are hard to store and obtain; their effectiveness can be limited by epidermis rejection; and the process of cryopreservation is expensive (Demling et al., 2004). Glycerol preserved allografts are often preferred in many skin banks due to lower costs and easy handling and storage. However, when processed and stored this way, glycerol preserved allografts do not provide cellular metabolic activity making this non-viable graft only a temporary covering to improve the wound bed for autografts (Atiyeh et al., 2005). Cadaveric skin allografts are still heavily used in preventing mortality in burn patients today.

Table 5. Advantages of Human allograft skin use
Reduce water, electrolyte, and protein loss
Prevent desiccation of tissue
Suppress bacterial proliferation
Reduce wound pain
Reduce energy requirements
Promote epithelialization
Prepare wounds for definitive closure
Provide dermal template for epidermal grafts

Note. From "Human Skin Banking," by R. J. Kagan, E. C. Robb, and R. T. Plessinger, 2005, *Clinics In Laboratory Medicine,* 25, p. 589. Copyright 2005 by Elsevier Inc.

Xenografts

Xenografts are another type of temporary skin covering for burn wounds. They are made of skin from another species, and currently pig skin is used (Shores, Gabriel, Gupta, 2007). Xenografts are not as effective as homograft's (another term for human allograft), and do not revascularize epithelium (Demling et al., 2004). Advantages of xenografts include: lower cost, ready availability, good adherence to wound, and decreased pain to recipient compared to other bioengineered products (Demling et al., 2004). Disadvantages of these types of grafts include the fact that they do not revascularize, can only be used short term, and must be frozen (Demling et al., 2004). Xenografts are still widely used in superficial second degree burn and donor sites, but are not as effective as allografts (Demling et al., 2004).

Human Amniotic Membrane

Another type of temporary graft covering that is occasionally used today is the human amniotic membrane from placentas (Shores et al., 2007). The human amniotic membrane has been used as a wound covering to treat epithelial burns since 1910. Is use has decreased due to the use of xenografts starting in the 1960's (Shores et al., 2007). This transparent membrane acts

as a barrier and also decreases pain to the recipient (Shores et al., 2007). Although this amniotic membrane can be used as a temporary barrier, it has several disadvantages. It is difficult to obtain, prepare, and store, and has to be changed every 2 days due to minimal adherence (Shores et al., 2007). This type of graft could also transmit infectious diseases (Shores et al., 2007).

Oasis® Wound Matrix

Another type of burn barrier is Oasis® Wound Matrix which is used for partial-thickness burns or donor sites and is not to be used for third degree burns (Demling et al., 2004). It is predominantly used in wounds that are difficult to heal after the standard of care has failed (Demling et al., 2004). This xenograft is derived from a pig's small intestinal submucosa (Demling et al., 2004). There are several advantages that this xenograft provides including: a long shelf life of up to 2 years at room temperature, reasonable cost, and less frequent changes as it does not need to be removed and can be applied weekly (Schaum & Farley, 2006). This type of graft contains extracellular matrix factors, including collagen and glycosaminoglycans (Schaum & Farley, 2006). Mostow and colleagues (2005) conducted a study on the treatment of chronic leg ulcers comparing the existing standard of care with the use of Oasis® Wound Matrix. The randomized clinical study showed that using an application of Oasis® with compression therapy resulted in improved healing of leg ulcers when compared to just compression therapy alone (Mostow et al., 2005). This study, along with others shows the effectiveness of this graft in providing the recipient with wound healing.

Biobrane™

Biobrane™ is another alternative for burn wounds. This barrier consists of a silicone layer and a nylon mesh containing collagen peptides (Demling et al., 2004). This can be used for the superficial burn or excised burn wound, is relatively inexpensive, can be stored at room

temperature, and has a long shelf life (Demling et al., 2004). The decreased bioactivity and difficult removal if left on for more than 2 weeks are some disadvantages of using this product (Demling et al., 2004). Biobrane™ along with other temporary burn wound coverings helps to decrease recovery time and recipients pain.

Transcyte™

Transcyte™ is a temporary translucent wound covering for superficial to mid-dermal burns and for use after wounds have been excised for closure (Demling et al., 2004). This temporary skin alternative has a synthetic silicone epidermis layer and a dermal layer comprised of bioactive dermal components, including neonatal human fibroblast cells, matrix proteins, and growth factors (Demling et al., 2004). This temporary skin substitute decreases pain and initiates epithelium growth (Demling et al., 2004). A disadvantage of this product is that it is relatively expensive and needs to be frozen until use (Demling et al., 2004). Transcyte™ possibly contributed in saving lives after the September 11th, 2001, terrorist's attacks at the Pentagon in Washington (Clark, 2001). After these attacks, the Washington hospitals could not supply the ten burn victims with second and third degree burns with a skin barrier. Regional hospitals around the country shipped grafts and supplies to Washington in efforts to help these victims. Even though these efforts helped with assistance, they still did not meet the demands for these burn victims. Due to inhibited transportation since airports were closed and because not all storage requirements could be met, not all available resources could be utilized during this time. Therefore, the company which makes Transcyte™ contacted FEMA and conducted an emergency delivery with federal assistance that may have saved the lives of these victims (Clark, 2001). This product could potentially help to supply burn victims in the US with temporary wound coverings when allograft supplies are not readily available.

Other Skin Substitutes

Temporary skin substitutes described above are not the only option in the absence of an allograft supply. In severe burns where full thickness skin loss is present, permanent skin substitutes may be used. Many permanent skin substitutes are still in the developing stages and not commercially available; the following discussion is limited to the few that are available today (Table 6) (Demling et al., 2004). Epicel® permanent skin grafts can be used for full-thickness or deep dermal burns that cover over 30 percent of recipients TBSA (Schlatter, 2011). Epicel® is grown by using a biopsy from an area of the recipient's healthy skin or skin that was not affected by the injury, which is then placed and grown on a layer of mouse cells to initiate the growth process (Schlatter, 2011). This cultured epidermal autograft can take up to 2 to 3 weeks to grow, only produces the epidermis layer, is very fragile, is expensive, and must be used upon delivery (Schlatter, 2011). Alloderm® is used for full-thickness or deep partial burns and for soft tissue replacement, has a shelf life of 2 years, and requires no specialized refrigeration (Shores et al., 2007). These donated grafts come from AATB accredited skin banks which are then processed by LifeCell to remove the epidermis and cells, thus preventing rejection (Demling et al., 2004). This acellular dermis is expensive, not commonly used in large burns, and requires another surgery to graft the epidermis layer (Demling et al., 2004). Integra® is comprised of two layers; the lower layer contains bovine collagen-cow protein and a glycosamineoglycan that is attached to the upper silicone layer as reported from National Institute of Health (NIH) (2008). After the excision of a burn wound, Integra® is then permanently grafted on the wound.

Table 6. Available Permanent Skin Substitutes

Product	Company	Tissue of Origin	Layers	Category	Uses	How Supplied
Apligraf	Organogenesis Inc and Novartis Pharmaceuticals Corp	Allogenic Composite	Collagen matrix seeded with human neonatal keratinocytes and fibroblasts	Composite: Epidermis and Dermis	Chronic wounds, often used with thin STSG Excised deep burn	7.5cm diameter disc 1/pack
OrCel	Ortec International Inc.	Allogenic Composite	Collagen sponge seeded with human neonatal keratinocytes and fibroblasts	Composite: Epidermis and Dermis	Skin graft donor site, chronic wounds	6x6cm sheets
Epicel	Genzyme Tissue Repair Corp	Autogenous keratinocytes	Cultured autologous keratinocytes	Epidermis Only	Deep partial and full thickness burns >30% TBSA	50cm2 sheets in culture medium
Alloderm	Life Cell	Allogenic dermis	A cellular Dermis (processed allograft)	Dermis only	Deep partial and full thickness burns, Soft tissue replacement, Tissue patches	1x2cm to 4x12cm
Integra	Integra Life Science Corp	Synthetic	Silicone outer layer on collagen GAG dermal matrix	Biosynthetic Dermis	Full thickness soft tissue defects definitive "closure" requires skin graft	2x2 inch 4x10 inch 8x10 inch 5/pack

Note. From "Managing The Burn Wound: Use of Skin Substitutes," by R. H. Demling, D. P. Orgill, and L. DeSanti, 2004. Copyright by burnsurgery.org.

After two to four weeks the recipient's own cells grow a neodermis, the silicone layer is then removed and an epidermis autograft is placed (NIH, 2008). Relative expense, possible hematoma or seroma formation, and a lengthy process are disadvantages of this skin substitute

(Shores et al., 2007). The permanent skin substitutes described above are used in clinical practice today. However, even though research has established alternate burn wound coverings, "skin on skin" grafting is preferred (D. Wilson, personal communication, January 19, 2011).

Discussion

American Burn Association Emergency Response Critique

The ABA has devised a mass burn casualty emergency response plan to provide direction during an event of an accidental disaster or terrorist attack. The main focus of this plan is primary and secondary triaging. Primary triage of burn victims is completed at the scene or local Emergency Department and is followed by appropriate transport to the nearest burn center. Secondary triage focuses on transporting burn casualties out to other burn centers once theses initial specialty centers have met their full capacities. In order for this system to function properly, appropriate transfer agreements, vehicles, and personnel are required. Once federal assistance is initiated during a disaster, FEMA supplies the area with the resources outlined in ESF #8, and burn specialty teams equipped with the capabilities of regional burn centers (Barillo et al., 2006). The NRF and the ABA's response plan for burn casualties show inconsistencies; the ABA response plan calls for triaging burn victims away from the disaster site and towards the nearest burn center, but the NRF plans to supply burn specialty teams and equipment to assist treatment at the scene once federal involvement is initiated (Barillo et al., 2006). The Southern Region burn disaster plan takes a more flexible approach which involves assessing the communities' situation and resources available to determine if burn victims will be triaged away from the disaster or if specialty personal will be provided by the community at the disaster site (Barillo et al., 2006). Incongruent approaches to disaster burn response are present in all three response plans described above. The ABA should combine different burn casualty responses

into one cohesive plan suggested by the Southern Region plan, considering different situations and available allocated resources. The ABA's emergency response plan for burns could be revised to accommodate each different situation and incorporate alternant response actions from local, state and federal response plans.

National Response Framework Critique

The NRF is the nation's guide to produce an "all hazards" response, along with its companion document, National Incident Management Systems (NIMS) that provides a national template for disaster response (DHS, 2008). Also, the NRF is comprised up of ESF Annexes, Support, Incident, and Partner Guides (DHS, 2008). These Annexes provide information on incident types, coordination between resources, and references for key responder roles (DHS, 2008). Although the NRF provides an overview on (1) preparedness, (2) response, and (3) recovery, each phase pertains to "all hazards" (DHS, 2008) and thus lacks specific criteria on medical response for mass burn casualties incidents on a local or state level before federal intervention or arrival of ESF teams. In the event of a nuclear attack, first responders and medical personnel will need to triage and evacuate casualties from the scene to appropriate health care facilities. According to Aghababian and colleagues (2007) the three issues of concern when dealing with burn victims from a nuclear detonation are (1) elapsed time from injury to treatment, (2) transportation to health care facility, and (3) lack or availability of personnel to initiate treatment. Again, time is a crucial element when caring for burn victims, medicating for pain management, and providing topical antimicrobial ointment agents to decrease the onset of infection (Aghababian et al., 2007). However, responders to the incident will be delayed as both state and federal groups could take up to 24 to 72 hours before arriving with the appropriate supplies and equipment (Aghababian et al., 2007). Further delays could be

contributed to operations set up, data gathering and decision making, and coordination with local authorities (Aghababian et al., 2007). Aghababian and colleagues (2007) suggest that: (1) treatment for burns will require expansion of capabilities on site due to lack of facilities available for severe burns or lack of transportation and that (2) the local levels and communities should devise their own emergency response plans to help facilitate burn treatment until further assistance arrives. Therefore, the ABA's emergency burn plan should be used as a foundation for local and state response and incorporated in the NRF for this specific contingency. Despite efforts to provide both local and state levels the protocol for preparedness, the NRF and NIMS criteria lack guidance and recommendations that are specific to any particular area or region. Every region has strengths and weaknesses, and recognizing these assets or a lack thereof is essential in emergency planning at local levels.

Military triage and treatment of burn casualties could be used as a suggested resource or model for local and state emergency preparedness. There is a 5 to 10 percent incidence of burn injuries during combat caused by explosive devices or fires from these explosives similar to those resulting from terrorists attacks (Breederveld & Tuinebreijer, 2009). Even though burn casualties from military contingencies usually involve a younger population of healthier individuals, medical professionals will also be presented with other problems including multiple wounds, inhalation issues, and probable inhibited transportation to health care facilities similar to issues discussed in the BDLS manual for a nuclear event (Breederveld & Tuinebreijer, 2009; Aghababian et al., 2007). Breederveld and Tuinebreijer (2009) noted that prior to transportation of burn victims, first responders should first stabilize victims by initiating the guidelines for Advanced Trauma Life Support (ATLS) for life threatening issues. Local and state authorities should incorporate such practices into their emergency burn plans. Furthermore, Cancio and

Pruitt (2005) argue that each hospital, community, and region needs to have an established disaster plan specifically for mass burn casualties that are directed towards that region or community's strengths and weaknesses. At the site of the incident, effective triaging of mass burn casualties will utilize medical resources appropriately, and help to eliminate mass crowding at nearby hospitals thus maximizing time and resources (Sparkes, 1997). After education and review of military response for burn casualties, first responders and local health care facilities should create emergency plans similar to ABA's response model to decrease mortality and morbidity of burn victims.

Recommendations for a National Allograft Tissue Reserve

Even though the US has made strides towards attempting to prepare for a mass casualty burn incident, there is still no reserve of human cadaver allograft skin (D. Wilson, personal communication, January 19, 2011). Regardless of the advantages that other skin alternative may have, allografts are the desired choice when autograft availability is lacking (Villapalos et al., 2010). Wolfe and colleagues (1983) have reported that the use of allograft tissue has increased the survival rates for deep dermal or full thickness burns. Not only do allografts increase survival rates, they help to promote epithelium growth and autograft take (Burd, Lam, & Lau, 2002). The disadvantages of allografts are possible disease transmission and difficulties in obtaining and storing grafts (Demling et al., 2004). A national allograft reserve could help to address concerns of preparedness in burn victims by supplying emergent situations with resources to save these casualties.

In 2007 alone, the US distributed over 2,000 tissue allografts signifying a need for an international coding system for tracing tissues (Strong & Shinozaki, 2010). Product terminology nationwide and globally has inhibited standardization in coding. However, standardization of an

international coding system needs to be established to ensure safety of donor to recipient transplantation, transportation of grafts, and monitoring a source of tissue availability (Strong & Shinozaki, 2010). The World Health Organization (WHO) Guiding Principles on Human Cell Tissue and Organ Transplantation recognizes the need for a congruent global coding system to identify tissues for the obvious safety benefits (Strong & Shinozaki, 2010). With adequate coding and traceability of allografts nationwide, the US would have a database of tissues that could be provided for emergencies.

Cryopreservation has been used as a means to preserve cadaveric skin allografts until transplantation on the recipient. Proper cryopreservation of allograft tissue can last up to 5 years, and still maintain variability (Ben-Basset et al., 2001). Therefore, under FDA regulations and recommendations of the AATB, storage of allografts could be maintained by cryopreservation and circulated by the ABA, or AATB's emergency task force. An organization assigned to maintaining this allograft reserve for emergency preparedness would necessarily need to circulate this reserve to ensure utilization of allografts prior to expiration at 5 years, and come up with a plan to transport such resources to appropriate burn centers by collaboration of both state and federal organizations. This model should include how the reserve organization will contact various burn centers and assess their needs, and how these resources will be transported. One limitation to obtaining enough cadaveric allograft tissue is the need of donors. Unlike blood donation which can be provided by living donors, skin has to come from a donation from a deceased individual. Insufficient knowledge, negative attitudes, and beliefs (Rykhoff et al., 2010) decrease the amount of organ and tissue donation. A study conducted by Rykhoff and colleagues (2010), presented 240 health sciences college students with an educational audiovisual presentation on the different aspects of tissue and organ donation, and the negative

misconceptions or beliefs towards donation. This study concluded that more education and awareness on organ and tissue donation in the health sciences curriculum can help to increase donation, since participants willing to donate after educational secessions increased from 52 to 63 percent (Rykhoff et al., 2010). Consequently, national organizations such as the ABA and AATB need to instill national education and awareness into their emergency preparedness so when the time of need comes, there will be an adequate supply available. Further education on tissue donation, and cryopreservation could be the start for a national allograft tissue reserve for emerging disasters and support for burn casualties.

Summary of Best Practices

Based on the research presented in this manuscript, recommendations or best practices to improve our nation's current situation include the following suggestions. It is recommended that the ABA's plan incorporate a flexible approach to triage response dependent on community available resources. If a burn casualty incident occurred in a rural area that lacked adequate trained healthcare personnel or facilities, and transportation was assessable, triaging to regional burn centers would be indicated. However, this may not always the case, and some communities may be adequately trained in burn care with the appropriate medical supplies. For instance, if transportation were blocked or inhibited and if federal aid were not available to assist the situation for the next 72 hours, primary and secondary triage to regional burn centers would not be possible. It would best for those communities' medical personnel and responders to triage and set up capabilities at the scene with resources that they can supply to treat burn victims to decrease casualties. The ABA plan should address situations in which the ability to transfer to a burn center is limited or absent and should identify changes in the plan for emergencies in which communities have advanced personnel or training in triage and burn casualties. If a collaborative

response effort were made to incorporate these changes, the ABA emergency burn plan would effectively save more lives.

The NRF lacks specific response criteria for incidents involving burn casualties and for this reason the NRF could improve by adding ABA guidelines for local levels. Burn victims are unique and require triaging with specialized care as opposed to other kinds of injuries. Local efforts would benefit from receiving guidance or recommendations from the NRF to effectively manage burn casualties. It is evident that each community will need to have a plan and be prepared if federal assistance like ESF teams or other organizations are unable to access the incident area. Local leaders and responders will need to analyze their emergency burn response plans, utilize their strengths, and resolve their weakness by using basic knowledge from the NRF and adopting specific criteria from the ABA's plan.

If a burn disaster or terrorist explosion were to occur producing mass amounts of burn casualties, the US would not have enough allograft tissue to save all individuals. Application of allografts significantly reduces pain, infection, and even death in burn victims. Without allografts, alternate skin substitutes may be used but are not as effective as allografts. Research has shown that cryoperserved allografts can last up to five years, and will still maintain viability and effectiveness. An opportunity for improvement would include the AATB maintaining an allograft tissue reserve since this tissue has a shelf life of up to five years if correctly cryopreserved. Like all tissue products, the reserve could be FDA regulated, and the AATB could sustain the tissue reserve by circulating older tissue to be used first and then restocking reserve with new allografts. If the US establishes an allograft skin reserve to be used for emergency situations, like the Strategic National Stockpile (SNS), burn casualties would have better outcomes.

Limitations

Several limitations in this study were present. Lack of available or recent data on burn disaster management dealing with mass casualties, tissue banking, and allografts all posed difficulties. There was also no research found regarding how the US could establish an allograft reserve for emergency situations or disasters. Also, there was no literature found that combined all emergency plans for burn casualties and then recommended which response would be the best to use. Therefore, further research on preserving allografts for disastrous situations and collaboration of multiple emergency response plans for burn victims among the different organizations would be recommended as mentioned previously.

Conclusion

Although lack of readiness has always been a threat, emergency preparedness has been a more recent focus for concern due to increased awareness of possible terrorists' attacks breaching the nation's defense systems. Adequate preparedness for such attacks or disasters that result in burn casualties are worth the time and resources spent to save lives ultimately. To help prepare logistically for burned individuals in a disaster, the US needs to establish an allograft reserve to help decrease deaths, prevent infection by providing these individuals with a barrier, and help to promote skin growth. The NRF provides communities with recommended guidelines and resources but does not provide specific guidance on response to certain situations or circumstances. The ABA provides an emergency burn response plan but there is no consistency with other state and federal plans. As a result, we need to implement the recommendations provided to ensure that our nation will be prepared and able to distribute adequate medical resources to burn victims when a disaster occurs.

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Appendix A

Major U.S. fire or burn disasters, 1900 to 2000

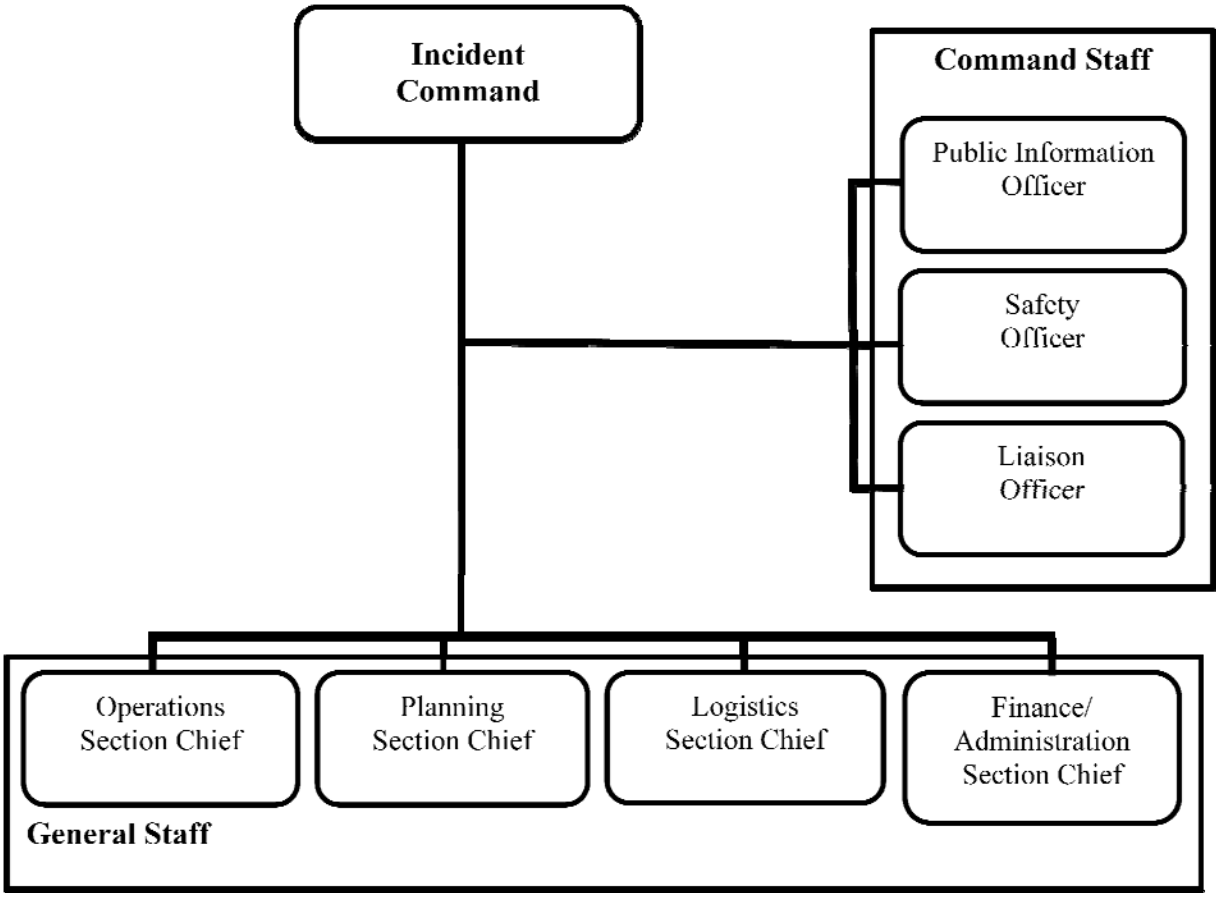
Date	Location	Fatalities	Injuries
June 30, 1990	Pier and ship fires, Hoboken, NJ	326	
October 20, 1902	Church fire, Birmingham, AL	115	
December 30, 1903	Iroquois Theater fire, Chicago, IL	602	220–250
June 15, 1904	General Slocum ship fire, New York, NY	1021	150
March 20, 1905	Grover & Co Shoe Factory, Brockton, MA	50	
April 18, 1906	Earthquake and fire, San Francisco, CA	500	
January 13, 1908	Rhoades Theater Fire, Boyertown PA	170	
March 4, 1908	Lakeview Elementary School, Collingwood, OH	176	70 burn patients
December 21, 1910	Stockyards fire, Chicago, IL	24 (21 firefighters)	15 injured
August 10, 1910	Forest fire, Bitterroot Mountains, ID	85	
November 25, 1910	Wolf Muslin Undergarment Co., Newark, NJ	25	
March 25, 1911	Triangle Shirtwaist Factory, New York, NY	146	70 seriously injured
July 21, 1913	Oakley Prison Farm Jackson, MS	35	
April 10, 1917	Munitions plant fire, Eddystone, PA	133	
April 13, 1918	Oklahoma State Hospital for Insane	38	
October 12, 1918	Forest fires, Cloquet & Moose Lake, MN	800	85 badly burned
June 20, 1919	Mayaguez Theater, San Juan, PR	150	
September 16, 1920	Wall Street Terrorist Explosion, New York, NY	40	
May 17, 1923	Cleveland Rural Grade School fire, Camden, SC	76	
December 24, 1924	Babb's Switch School, Hobart, OK	36	
May 15, 1929	Cleveland Clinic Fire, Cleveland, OH	125	
April 21, 1930	Ohio State Penitentiary fire, Columbus, OH	320	150 hospitalized
July 4, 1931	Home for the Aged, Pittsburgh, PA	48	
September 8, 1934	SS Moro Castle off, Asbury Park, NJ, Coast	134	
April 6, 1936	Hardware store, Gainesville, GA	57	
May 6, 1937	Hindenburg Airship fire, Lakehurst, NJ	35	
May 16, 1938	Terminal Hotel, Atlanta, GA	38	
April 23, 1940	Rhythm Nightclub Dance Hall fire, Natchez, MS	207	200
November 28, 1943	Cocoanut Grove Nightclub, Boston, MA	492	166 injuries
July 6, 1944	Gulf Hotel, Houston, TX	55	
June 5, 1946	Ringling Brothers Circus fire, Hartford, CT	168	261 seriously injured
June 9, 1946	LaSalle Hotel fire, Chicago, IL	61	200 injured
December 7, 1946	Canfield Hotel, Dubuque, IW	17	
December 12, 1946	Winecoff Hotel, Atlanta, GA	119	89 injured
April 16, 1947	Ice plant fire, New York, NY	37	
April 16, 1947	SS Grandchamp & SS High Flyer, Texas City, TX	581	800 hospitalized
April 5, 1949	St. Anthony Hospital fire, Effingham, IL	77	
Half-century			
January 7, 1950	Mercy Hospital, Davenport, IA	40	
May 25, 1950	Streetcar/gasoline truck fire, Chicago, IL	34	
March 29, 1953	Nursing Home, Littlefield, FL	33	

April 16, 1953	Haber Corporation, Chicago, IL	35	
February 12, 1955	Barton Hotel, Chicago, IL	29	
February 17, 1957	Katie Jane Home for the Aged, Warrenton, MO	72	
December 1, 1958	Our Lady of Angels School, Chicago, IL	95	93
December 19, 1960	USS Constellation, Brooklyn, NY	50	
November 18, 1969	Surfside Hotel, Atlantic City, NJ	26	
November 23, 1963	Golden Age Nursing Home, Fitchville, OH	63	
February 7, 1967	Dale's Penthouse Restaurant, Montgomery, AL	25	
July 16, 1967	Prison fire, Jay, FL	37	
August 11-16, 1965	Watts riot, Los Angeles, CA	34	
October 17, 1966	23rd Street fire, New York City	12 firefighters	
July 11-27, 1967	Riots, Newark, NJ, and Detroit, MI	23 (Newark) 43 (Detroit)	600
January 9, 1970	Nursing home fire, Marietta, OH	27	
December 20, 1970	Pioneer International Hotel, Tucson, AZ	28	
June 24, 1973	Upstairs Lounge Nightclub fire, New Orleans, LA	32	12 (10 "critically burned")
October 24, 1976	Social Club, Bronx, NY	25	
May 28, 1977	Beverly Hills Supper Club, Southgate, KY	165	70
June 26, 1977	Maury County Jail fire, Columbia, TN	42	
April 2, 1979	Retirement home fire, Farmington, MO	25	
November 21, 1980	MGM Grand Hotel, Las Vegas, NV	84	679
November 26, 1980	Stouffer's Inn, White Plains, NY	26	
January 9, 1981	Home for Elderly, Keansburg, NJ	30	
July 4, 1984	Boarding home fire, Beverly MA	15	9
October 18, 1984	Hotel fire, Paterson, NJ	15	70
December 31, 1986	Dupont Plaza Hotel fire, San Juan, PR	97	100
October 5, 1989	Nursing home fire, Norfolk, VA	12	96 injured or relocated
March 25, 1990	Happy Land Disco, Bronx, NY	87	At least 1 critical burn
September, 1991	Imperial Foods plant, Hamlet, NC	25	54
October 20-21, 1991	Oakland/Berkley Hills, CA, wildland fires	25	150
February 26, 1993	World Trade Center explosion and fire, NY	6	1042
March 16, 1993	Paxton Hotel Fire, Chicago, IL	20	28
July 6, 1994	Glenwood Springs CO, forest fire	14 firefighters	

Note. From "Planning for Burn Disasters: Lessons Learned From One Hundred Years of History," by D. J. Barillo and S. Wolf, 2006. *Journal of Burn Care & Research,* 27, p. 624-625. Copyright 2006 by the American Burn Association.

Appendix B

Incident Command Structure



Note. From "National Response Framework," by DHS, 2008, p. 49.

Appendix C

Response Plan Flow Chart

Step 1. Affected Blood Collector (BC) Assesses Medical Need for Blood

√ Contact local hospital customers and emergency services to determine impact of event, including:
- Nature of emergency (e.g., disaster, terrorism)
- Number of current and expected hospital admissions
- Types of expected injuries
- Potential effect on local donor base

√ Gather information on local blood inventory levels from both BC and hospital customers.

√ Calculate the medical need for blood for a nonbiological event based on three units of type O RBCs per current and expected hospital admissions resulting from the event (see Event Assessment Form).

Step 2. Affected BC Contacts AABB (ideally within 1 hour of event)

√ Contact AABB (use redundant communication channels in order listed below):
1. Land line: (800) 458-9388
2. Cell phone: (240) 994-6700
3. E-mail: nbe@aabb.org
4. Text message: (240) 994-6700
5. Satellite phone: (254) 377-3726

√ Report medical need and local blood inventories.

Step 3. Interorganizational Task Force (TF) Conference Call

√ AABB convenes a conference call with Level 1 TF members (Level 2 TF members included if necessary—see page 42 for a list of Level 1 and Level 2 TF member organizations).

√ TF determines national strategy and coordination efforts, including:
1. Message to blood community/donors
2. Transportation and coordination of blood to affected BC
3. Next steps until event is resolved

√ AABB communicates decisions to Level 2 TF members.

Step 4. Implementation of Task Force Recommendations

√ TF representatives communicate recommendations to their respective constituencies.

√ TF distributes unified message to blood community and donors (e.g., joint press releases).

√ TF coordinates message to the public with Department of Health and Human Services (HHS).

Note. From "Disaster Response," by AABB, 2011.

Appendix D

Public Health Competencies Met

Domain #1: Analytic Assessment skill
1. Defines a problem
2. Identifies relevant and appropriate data and information sources

Domain #2: Policy Development/Program Planning Skills
3. Collects, summarizes, and interprets information relevant to an issue.
4. Utilizes current techniques in decision analysis and health planning.

Domain #3: Communication Skills
5. Solicits input from individuals and organizations.
6. Advocates for public health programs and resources

Domain #4: Cultural Competency Skills
7. Develops and adapts approaches to problems that take into account cultural differences.
8. Identifies the role of cultural, social, and behavioral factors in determining the delivery of public health services.

Domain #5: Community Dimensions of Practice Skills
9. Identifies community assets and available resources.
10. Describes the role of government in the delivery of community health services

Domain #6: Basic Public Health Sciences Skills
11. Identifies and applies basic research methods used in public health
12. Identifies and retrieves current relevant scientific evidence.

Domain #7: Financial Planning and Management Skills

Domain #8: Leadership and Systems Thinking Skills
13. Applies the theory of organizational structures to professional practice
14. Creates a culture of ethical standards within organizations and communities.
15. Helps create key values and shared vision and use these principles to guide action
16. Identifies internal and external issues that may impact delivery of essential public health services (i.e. strategic planning).

Appendix E

IRB Exemption Letter

WRIGHT STATE UNIVERSITY

Office of Research and Sponsored Programs
201J University Hall
3640 Col. Glenn Hwy.
Dayton, OH 45435-0001
(937) 775-2425
(937) 775-3781 (FAX)
e-mail: rsp@wright.edu

DATE: 04/12/2011

TO: Jackie Tippett, P.I., Grad. Student
Mark Gebhart, M.D., Fac. Adv.
Emergency Medicine

FROM: B. Laurel Elder, Ph.D., Chair
WSU Institutional Review Board

SUBJECT: SC# 4465
'Nation's Future: Preparedness for Burn Victims'

Your study does not meet the definitions for human subjects research. Therefore the proposal submitted does not need approval from the Wright State University Institutional Review Board.

If you have any questions or require additional information, please call Jodi Blacklidge, Program Coordinator at 775-3974.

Thank you!