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Redefining the Outcomes to Resources Ratio for Burn Patient Triage in a Mass Casualty

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Abstract

Recent disasters highlight the need for pre-disaster planning, including the need for accurate triage. Data driven triage tables, such as that generated from the 2002 National Burn Repository (NBR), are vital to optimize resource utilization during a disaster. The study purpose was to generate a burn resource disaster triage table based on current burn treatment outcomes. Data from the NBR after the year 2000 were audited. Records missing age, burn size, or survival status were excluded from analysis. Duplicate records, readmissions, transfers, and non-burn injuries were eliminated. Resource utilization was divided into expectant (predicted mortality >90%), low (mortality 50–90%), medium (mortality 10–50%), high (mortality <10%, admission 14–21 days), very high (mortality <10%, admission <14 days), and outpatient. Tables were created for all patient admissions and with/without inhalation injury. Of the 286,293 records, 210,683 were from the year 2000 or later. Expectant status for those >70 years began at 50% burn; a 20–29 year old never reached expectant status. Inhalation injury lowered the expectant category to a burn size of 40% in >70 year old, and at >90% in 20–29 year olds. The 0–1.9 year old group without inhalation injury never reached expectant status; with inhalation injury, expectant status was reached at >80% burn. Changes in the triage tables suggest that burn care has changed in the past 10 years. Inhalation injury significantly alters triage in a burn disaster. Use of these updated tables for triage in a disaster may improve our ability to allocate resources.

Keywords

burn; disaster; triage

Introduction

A multitude of serious events at the beginning of the 21st century triggered an acute awareness of the need for disaster planning among federal, state, and local agencies as well as health care providers. As a result, disaster planning assumed increased importance in many professional societies and state agencies. The cornerstone of all of these efforts is the development of mechanisms to identify and prioritize patient treatment during a mass

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casualty incident. In a true mass casualty incident, medical resources are likely to be overrun, and care will need to be prioritized to optimize the survival for the greatest number of people. The concept of triage, which prioritizes care to the patients who have the greatest chance of survival, previously foreign to many developed countries, has been introduced to health care providers. The advantage of triage is that it maximizes survival for the greatest number of people. The disadvantage of triage is that it may deny treatment to severely injured patients who may have been salvaged if numerous resources were used. As such, triage is for the benefit of the many as opposed to the benefit of the few. Triage is not appropriate for day to day patient care and should be reserved for true disasters.

In an effort to help define optimal resource utilization during a disaster, Saffle et al developed a burn resource utilization diagram based on the 2002 National Burn Repository in January 2002. (1) This table has been adopted into the American Burn Association disaster management protocol. (2) This table incorporated burn size, patient age, and resources used, including hospital length of stay and number of operations into its determinations. It was anticipated that this document could be used by burn experts working in conjunction with mass casualty directors in the event of a disaster that overwhelmed local resources and forced the selective delivery of care to the burn patient. This "burn triage table" has formed the basis of regional disaster protocols. (3,4) The data used to create this table are now more than 10 years old. In addition, the data were obtained from the NBR annual report, which had limited data auditing. Finally, the table included patients both with and without inhalation injury, one of the leading determinants of survival and resource utilization after burn injury. (1)

The purposes of this paper were to 1. update the resource utilization diagram using rigorously reviewed data from the 2000–2009 NBR and 2. assess how the triage table would change with consideration of inhalation injury. We hypothesized that burn mortality improved in the last 10 years and that inhalation injury would yield important refinements to the burn triage table.

Methods

This project was approved by the University of California Davis Institutional Review Board. The National Burn Repository (NBR) contains patient, injury characteristics, and outcomes for patients admitted to burn centers for treatment of burns and related medical conditions. We obtained a deidentified version of the American Burn Association's 2009 release of the NBR containing 286,293 admission records. To focus on recent burn care and outcomes, we restricted our analysis to admissions in 2000 or later (210,683).(5) We dropped records missing information on survival to discharge (12,226), age (5,441), or burn size (42, 545). We also removed 3,218 records identified as probable duplicates (5Taylor et al 2012), 6,529 records with unreliable information (i.e. total burn surface area greater than 100, unreasonable age or mortality rates), 23,084 records associated with readmissions, and 3,690 records of patients with non-burn injuries. Finally, we dropped 1,038 records of patients transferred to another hospital for acute care. This screening left 112,912 records of initial hospital visits (admissions and outpatient visits) with the minimum information for necessary analysis (i.e. patient age, a burn or inhalation injury, and hospital discharge status).

Patient outcomes were assessed initially based on burn size and age only. Survival was calculated for each age and TBSA group. Triage status was defined as per previous publication (1) into 6 priority groups: Outpatient, Very High, High, Medium, Low, and Expectant. (Table 1). Each age and TBSA burn category were placed into one of the priority groups based on survival, length of stay, and number of operations as defined in Table 1.

Due to the profound impact of inhalation injury on patient outcomes, we then performed the same analysis for patients with inhalation injury and without inhalation injury to determine if this changed triage category.

Results

Burn survival is depicted in Table 2 based on mortality, length of stay and the number of operative procedures by age and burn size. Table 3 shows the triage category criteria for patients of all ages and burn size combinations. All records with age and burn size information are included irrespective of information on inhalation injury. Tables 4a and 4b, show the same information, but split out according to the presence of inhalation injury. Of note, the triage level changed based on presence or absence of inhalation injury, particularly at the extremes of age. For example, the "expectant" category was at >50% TBSA burn for patients >70 years of age overall (Table 3). However, when patients >70 years of age had inhalation injury in addition to burn injury, they achieved "expectant" status at a TBSA >40%. Likewise, in children <2 years of age, patients were in the "low" category for TBSA >80% TBSA (Table 3); however, with inhalation injury (Table 4b), these patients became "expectant" with the same size burn. Without inhalation injury, children <2 years of age with a >80% TBSA burn without inhalation injury fall into the "medium" triage category (Table 4a). These survival differences are likely in part due to the lack of pulmonary development (in children prior to 2 years of age) or lack of pulmonary reserve (elderly). This effect was less pronounced in patients 20–40 years of age.

Conclusions

The first widely publicized "read" of age and burn size driving methodical burn mass casualty triage published by Saffle, et al marked an important juncture in burn disaster management: development of burn disaster triage plan PRIOR to an event based on analysis of a nation-wide data repository. Saffle's paper demonstrated several concepts: first, that burn care professionals were going to embrace disaster preparedness, second, that surgeons would prioritize based on resource/survival benefit, and third, that disaster preparedness triage would be based on data, not administrative needs, emotion, or "local wisdom". No system for estimating burn resource utilization is perfect, however. The initial attempt at a triage diagram, with an emphasis on simplicity and ease of application, did not include inhalation injury in its resource and mortality calculations. As multiple authors have cited, inhalation injury is, in fact, a major determinant of burn survival and resource utilization. (6,7). We designed triage tables to specifically assess the impact of inhalation injury on the triage paradigm. Notably, inhalation injury markedly increases predicted mortality for two groups: children and the elderly. For example, an 18 month old (1.5 years) with an 80% TBSA burn would be in a "low" priority for disaster triage in the consolidated model, and in the "expectant" category in the inhalation table. However, that same child would be in the "medium" category in the no inhalation injury table. In a true disaster, low priority and expectant patients are given few resources. Hence, an 18 month old without inhalation injury would currently be a low priority, when in reality that child should be actively treated.

No burn care professional desires to apply the triage criteria. To do so admits that our current systems are overrun and that we are unable to care completely for all patients. However, the reality is that, in a disaster, we will not be able to take care of everyone. There simply will not be sufficient resources. Making an objective determination of where to allocate resources prior to a disaster improves the quality of decision-making, reduces stress for providers in the disaster, and assures the public that there is an organized plan for major incidents. We must take care that the system we create is as accurate as possible. As the sophistication and accuracy of the NBR increases, our ability to develop easy-to-use, meaningful, and accurate triage methods will continue to improve. Our report represents the first to revisit the triage criteria using an updated data set and adding a single mortality predictor: inhalation injury.

One must always acknowledge the limitations of any method for triage prediction. The NBR, while it is the best source of burn data, has several limitations, which we have previously described (5). First, it is a voluntary registry with limited data auditing. Second, several different computer software versions have been applied to the registry, and not all burn centers have contributed to the registry. Data entry issues and incomplete data may well create data bias. In addition, the utilization of resources and outcomes may be different in a disaster. For example, children <1 year old are in the "very high" category because the majority are currently admitted and utilize hospital resources. This may not be the practice in a disaster. Finally, burn outcomes in a disaster situation may not necessarily match those under "normal" circumstances, and extrapolating outcomes may not represent actual resource needs.

Burn injury is unique in that the ability to predict outcomes can be based on just three criteria: age, percent burn, and inhalation injury (8–10). This has both advantages and disadvantages. Having defined criteria lends mass burn casualty response a great "leg up" in constructing thoughtful and sensible cut-offs for expectant/no-treatment levels of injury—perhaps more so than any other injury type expected from mass-casualties. However, even three criteria may be too complicated in times of disaster. The determination of whether or not inhalation injury is present can be challenging for first responders. As such, the initial triage table does not consider inhalation injury.

If the reader is looking for an executive summary to apply to all situations a turn-key answer to the task "who's treated and who's not", then refer to Figure 1 which presents the ultra-simplified data without consideration for inhalation injury. In this model burn size is the major independent variable. This approach simplifies the initial triage task and results in an all-in-one matrix for data presentation, which trades fidelity (and probably more lives saved) for simplicity and do-ability. However, disaster planners must be aware that this simplistic approach will result in differences in triage categorization, especially for children.

If policy makers (and their collaborative, methodical, reflective analysis—both health care providers and government agencies) are able to take a more nuanced approach to the task, the discussion must veer into separate data tables with- and without- inhalation injury, and discussion of two critical concepts/terms: Situational Awareness and Scalability. Situational Awareness, or a "God's Eye View" of the unfolding and dynamic mass casualty event is a pre-requisite for applying more nuanced triage tables. What must be avoided at all costs is bad situational awareness leading to the deployment of triage criteria either too sparing or too liberal of the decision to withhold care, assuming that maximum collective good of those injured is the over-arching goal. In the case of burn injury, applying the general table during a mass inhalation/burn incident would waste resources. Scalability addresses the vastly dynamic nature and natural history/evolution of any mass casualty situation.

To have Situational Awareness at any given moment in the natural history of an event is not enough to secure maximum good. Conditions change, the "fog of war" descends rapidly and unforgivingly, and serendipitous good breaks occur that need to be recognized and taken advantage of. Finally, the triage tables used for "rules of engagement", and the clinical response that results must be able to dynamically "scale" or "telescope" up and down, greater or lesser, as the dynamics unfold. To date, triage tables are static; the future may well permit development of dynamic triage tables.

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Burn disasters happen. As burn professionals, we must take an active role in preparing ourselves for mass burn casualties. Development of triage tables in advance of a disaster will not solve every problem; however, it is an important first step in disaster planning. Current triage paradigms are simple to assure applicability and understanding during a time of crisis. We must balance simplicity with accuracy to ensure that victims of a disaster receive the best medical care possible given limited resources.

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References

1. Saffle JR, Gibran N, Jordan M. Defining the ratio of outcomes to resources for triage of burn patients in mass casualties. J Burn Care Rehabil. 2005; 26:478–82. [PubMed: 16278561]
2. ABA Board of Trustees, and Committee on Organization and Delivery of Burn Care. Disaster Management and the ABA plan. J Burn Care Rehabil. 2005; 26:102–6. [PubMed: 15756109]
3. Leahy NE, Yurt RW, Lazar EJ, Villacara AA, et al. Burn disaster response planning in New York City : Updated recommendations for best practices. J Burn Care Res. 2012; 33:587–94. [PubMed: 22964548]
4. Conlon KM, Martin S. Just send them all to a burn centre': managing burn resources in a mass casualty incident. J Bus Cont Emerg Plan. 2011; 5:150–60.
5. Taylor SL, Lee D, Nagler T, Lawless MB, Curri T, Palmieri TL. Validity Review of the National Burn Repository. J Burn Care Res. 2012 Nov 6. in press.
6. Smith DL, Cairns BA, Ramadan F, et al. Effect of inhalation injury, burn size, and age on mortality: a study of 1447 consecutive burn patients. J Trauma. 1994; 37:655–9. [PubMed: 7932899]
7. Wolf SE, Rose JK, Desai MH, Mileski JP, Barrow RE, Herndon DN. Morality determinants in massive pediatric burns. An analysis of 103 children with > or = 80% TBSA burns. Ann Surg. 1997; 225:554–565. [PubMed: 9193183]
8. Colohan SM. Predicting prognosis in thermal burns with associated inhalational injury: a systematic review of prognostic factors in adult burn victims. Burn Care Res. 2010 Jul-Aug;31(4):529–39.
9. Sheppard NN, Hemington-Gorse S, Shelley OP, Philp B, Dziewulski P. Prognostic scoring systems in burns: a review. Burns. 2011 Dec; 37(8):1288–95.
10. Ryan CM, Schoenfeld DA, Thorpe WP, Sheridan RL, et al. Objective estimates of the probability of death from burn injuries. N Engl J Med. 1998 Feb 5; 338(6):362–6. [PubMed: 9449729]

Table 1

Resource Utilization Criteria Categories

Outpatient: No admission required, survival ≥95%
Very High: Survival ≥90%; length of stay ≤14–21 days, 1–2 operations
High: Survival ≥90%; length of stay 14–21 days, multiple operations
Medium: Survival >50 and <90% (mortality 10–50%)
Low: Survival >10 and <50% (mortality 50–90%)
Expectant: Survival ≤10% (mortality ≥90%)

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Table 2

Mortality (number of deaths/number of records) for burn patients grouped by age and burn size. All records (N=112,912) irrespective of inhalation injury.

	Burn Size Group, % TBSA									
Age Group	**[0–10)**	**[10–20)**	**[20–30)**	**[30–40)**	**[40–50)**	**[50–60)**	**[60–70)**	**[70–80)**	**[80–90)**	**≥ 90**
0–1.99	6/11447	6/2209	7/419	8/156	5/56	4/27	10/26	5/15	8/13	3/4
%	0.1	0.3	1.7	5.1	8.9	14.8	38.5	33.3	61.5	75.0
2–4.99	11/6051	1/1287	4/352	11/172	8/88	9/50	3/38	10/30	16/27	13/20
%	0.2	0.1	1.1	6.4	9.1	18.0	7.9	33.3	59.3	65.0
5–19.99	27/13414	9/2911	12/864	12/422	16/251	12/162	20/115	16/72	37/70	42/59
%	0.2	0.3	1.4	2.8	6.4	7.4	17.4	22.2	52.9	71.2
20–29.99	41/11897	20/2837	22/915	24/422	22/211	32/152	30/111	29/62	40/71	62/74
%	0.3	0.7	2.4	5.7	10.4	21.1	27.0	46.8	56.3	83.8
30–39.99	49/10519	20/2708	29/881	26/391	32/236	37/128	36/105	53/87	51/68	80/84
%	0.5	0.7	3.3	6.6	13.6	28.9	34.3	60.9	75.0	95.2
40–49.99	80/11135	48/2863	51/998	61/475	74/256	79/173	54/118	56/79	55/68	102/105
%	0.7	1.7	5.1	12.8	28.9	45.7	45.8	70.9	80.9	97.1
50–59.99	99/7542	64/1951	70/686	81/334	73/195	74/135	75/100	56/61	51/55	69/71
%	1.3	3.3	10.2	24.3	37.4	54.8	75.0	91.8	92.7	97.2
60–69.99	110/3906	92/1153	90/427	78/188	63/104	45/62	37/42	31/34	33/34	39/41
%	2.8	8.0	21.1	41.5	60.6	72.6	88.1	91.2	97.1	95.1
≥ 70	306/4065	324/1369	280/532	186/271	150/169	96/103	72/73	67/69	38/40	44/44
%	7.5	23.7	52.6	68.6	88.8	93.2	98.6	97.1	95.0	100.0
Total Mortality	**729/79976**	**584/19288**	**565/6074**	**487/2831**	**443/1566**	**388/992**	**388/728**	**337/509**	**323/446**	**454/502**
Total Mortality (%)	**0.9**	**3.0**	**9.3**	**17.2**	**28.3**	**39.1**	**53.3**	**66.2**	**72.4**	**90.4**

Table 3

Triage Table Based on All Patients

	Burn Size Group, % TBSA All									
Age	**0–9.9**	**10–19.9**	**20–29.9**	**30–39.9**	**40–49.9**	**50–59.9**	**60–69.9**	**70–79.9**	**80–89.9**	**≥ 90**
0–1.99	Very High	Very High	High	High	High	Medium	Medium	Medium	Low	Low
2–4.99	Outpatient	Very High	High	High	High	Medium	Medium	Medium	Low	Low
5–19.99	Outpatient	Very High	High	High	High	High	Medium	Medium	Low	Low
20–29.99	Outpatient	Very High	High	High	High	Medium	Medium	Medium	Low	Low
30–39.99	Outpatient	Very High	High	High	Medium	Medium	Medium	Low	Low	Expectant
40–49.99	Outpatient	Very High	High	Medium	Medium	Medium	Medium	Low	Low	Expectant
50–59.99	Outpatient	Very High	High	Medium	Medium	Low	Low	Expectant	Expectant	Expectant
60–69.99	Outpatient	High	Medium	Medium	Low	Low	Low	Expectant	Expectant	Expectant
≥ 70	Very High	Medium	Low	Low	Low	Expectant	Expectant	Expectant	Expectant	Expectant

Table 4a

Triage Table Non-Inhalation Injury

	Burn Size Group, % TBSA NO Inhalation Injury									
Age	**0–9.9**	**10–19.9**	**20–29.9**	**30–39.9**	**40–49.9**	**50–59.9**	**60–69.9**	**70–79.9**	**80–89.9**	**≥ 90**
0–1.99-	Very High	Very High	High	High	High	High	Medium	Medium	Medium	Medium
2–4.99	Outpt	Very High	High	High	High	High	High	Medium	Medium	Medium
5–19.99	Outpt	Very High	High	High	High	High	High	Medium	Medium	Low
20–29.99	Outpt	Very High	High	High	High	Medium	Medium	Medium	Medium	Low
30–39.99	Outpt	Very High	High	High	Medium	Medium	Medium	Low	Low	Expectant
40–49.99	Outpt	Very High	High	High	Medium	Medium	Medium	Low	Low	Expectant
50–59.99	Outpt	Very High	High	Medium	Medium	Low	Low	Expectant	Expectant	Expectant
60–69.99	Very High	High	Medium	Medium	Low	Low	Expectant	Expectant	Expectant	Expectant
≥ 70	High	Medium	Medium	Low	Low	Expectant	Expectant	Expectant	Expectant	Expectant

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Table 4b

Triage Table Inhalation Injury

	Burn Size Group, % TBSA WITH Inhalation Injury									
Age	**0–9.9**	**10–19.9**	**20–29.9**	**30–39.9**	**40–49.9**	**50–59.9**	**60–69.9**	**70–79.9**	**80–89.9**	**≥ 90**
0–1.99	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Expectant	Expectant
2–4.99	High	High	High	High	High	Medium	Medium	Medium	Low	Low
5–19.99	High	High	High	High	Medium	Medium	Medium	Medium	Low	Low
20–29.99	Very High	High	High	Medium	Medium	Medium	Medium	Low	Low	Expectant
30–39.99	Very High	High	High	Medium	Medium	Medium	Medium	Low	Low	Expectant
40–49.99	Very High	High	Medium	Medium	Medium	Low	Low	Low	Low	Expectant
50–59.99	High	Medium	Medium	Medium	Medium	Low	Low	Expectant	Expectant	Expectant
60–69.99	Medium	Medium	Medium	Low	Low	Low	Expectant	Expectant	Expectant	Expectant
≥ 70	Medium	Medium	Low	Low	Expectant	Expectant	Expectant	Expectant	Expectant	Expectant