Epidemiology and outcomes of pediatric burns over 35 years at Parkland Hospital

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This abstract was presented as a poster at the 2015 annual American Burn Association.

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article. Research reported in this publication was supported by the National Institute for General Sciences of the National Institutes of Health under award number T32GM008593; and the United States Army Medical Research Administration, TATRC, Department of Defense grant number W81XWH-12-2-0074-01.

Pediatric burns: 35 years at Parkland

Background:

Since opening its doors in 1962, the Parkland Burn Center has played an important role in improving the care of burned children through basic and clinical research while also sponsoring community prevention programs. The aim of our study was to retrospectively analyze the characteristics and outcomes of pediatric burns at a single institution over 35 years.

Study Design:

The institutional burn database, which contains data from January 1974 until August 2010, was retrospectively reviewed. Patients older than 18 years of age were excluded. Patient age, cause of burn, total body surface area (TBSA), depth of burn, and patient outcomes were collected. Demographics were compared with regional census data.

Results:

Over 35 years, 5,748 pediatric patients were admitted with a thermal injury. Males comprised roughly two-thirds (66.2%) of admissions. Although the annual admission rate has risen, the incidence of pediatric burn admissions, particularly among Hispanic and African American children has declined. The most common causes of admission were scald (42%), flame (29%), and contact burns (10%). Both the median length of hospitalization and burn size have decreased over time ($r^2 = 0.75$ and 0.62 , respectively). Mortality was significantly correlated with inhalation injury, size of burn, and history of abuse. It was negatively correlated with year of admission.

Conclusions:

Over 35 years in North Texas, the median burn size and incidence of pediatric burn admissions has decreased. Concomitantly, length of stay and mortality have also decreased.

Abbreviations

TBSA = total body surface area
LOS = length of stay
CPS = Child Protective Services
IQR = interquartile range
OR = odds ratio
CI = confidence interval

Under the guidance of Dr. Charles Baxter, the Parkland Burn Center in Dallas, Texas, opened in 1962 as the regional burn center for adults and children of North Texas. The Parkland Burn Center served as a proving ground for Dr. Baxter's burn resuscitation formula and remains at the forefront of burn care today [1]. During his years leading the Parkland Burn Center, Dr. Gary Purdue established a database to collect patient demographics, details of each injury, patient treatments, and outcomes. This database was retrospectively collected for data from 1974 until 1983 and then prospectively maintained from 1983 until 2010. This database presents an opportunity to evaluate the changing epidemiology and outcomes of pediatric burns in the North Texas region over a 35-year period.

Methods

Following Institutional Review Board approval, the Parkland Burn Center database was queried for all data points. During the study period, 17,125 patients were admitted to the Parkland Burn Center. For this investigation, only patients aged 18 or younger were included ($n = 5,959$). The majority of analyses were performed on the subset of patients admitted for new thermal injuries including inhalation injury with or without cutaneous burn ($n = 5,748$). This subset will be referred to as the "burn admissions." The data collected included patient gender, age, race/ethnicity, Texas resident status, details regarding the mechanism of injury, percent total body surface area (TBSA) burn, physician documentation of inhalation injury, length of stay, referral to Texas Child Protective Services (CPS), details of discharge, and in-hospital as well as outpatient mortality. Admissions were divided into short stay (1-2 days) and standard stay (>2 days). Prior to analysis, any missing, inconsistent, and out-of-range data points were corrected from free text comments or the medical record where possible. Less than 1% of all data points were missing or unknown after 1978. Between 1974 and 1978, the

cause of injury was missing in 25% of admissions and discharge status was missing in 12%. The in-state burn patients were compared to the North Texas population. Census and demographic information from 1990 to 2009 was obtained on-line from the Texas Department of State Health Services [2].

The incidence of burn admission was calculated as the number of events among patients identified as Texas residents per 100,000 of the relevant population per year. Mortality analysis was performed on all burn admissions, with a second analysis on burn admissions with in-hospital mortality after 24 hours of admission. The revised Baux score (rBaux) was used to model risk of mortality and compare outcomes over the 35 years ($\text{rBaux} = \text{age} + \text{TBSA}\% + 17 \times \text{inhalation injury}$) [3,4]. Statistical analysis was performed using Chi-square, ANOVA, linear regression, and multivariable logistic regression where appropriate. Microsoft Excel™ (2010), Systat SigmaPlot® (12.5), and SPSS PASW® Statistics (17) were used in this analysis.

Results

Between January 1974 and August 2010, 5,959 patients aged 18 years or younger were admitted to the Parkland Burn Center. Over 96% ($n = 5,748$) of admissions were due to a thermal injury. The majority of burned children (98.6%) resided in Texas ($n=5,668$). Based on this population, the incidence of burns in our catchment area peaked in 1979 and has steadily decreased since the 1980s ($r^2 = 0.51$); although we did note a smaller secondary peak in the 1990s (Fig. 1). The average size of burn injuries has also been decreasing over time; the median and 75th percentile of burn size have significantly decreased over the 35 years ($r^2 = 0.41$ and 0.62 , respectively). Concomitantly, the overall median length of hospitalization has been decreasing over time ($r^2 = 0.75$) (Fig. 2). When the length of stay (LOS) was controlled for TBSA burn (excluding mortalities), median LOS significantly decreased from 1.5 days

per TBSA (0.9, 3.4 [IQR]) in 1976 to 0.5 days per TBSA (0.25, 1 [IQR]) in 2010 ($r^2 = 0.77$) (Fig. 3). The proportion of children who are managed during a short stay admission (1-2 days) increased from less than 10% of admissions in the 1970s to 50% of admissions in the 2000s ($r^2 = 0.79$) (Fig. 1).

The most common mechanisms of injury were scald (42%), flame (29%), and contact burns (10%). Between 1979 and 2010, there was no significant trend in the cause of all admissions to the burn center when categorized into scald, flame, contact, grease, or “other” ($p = 0.23$) (Fig. 6). “Other” indications for admission included electrical burn, chemical burn, traumatic soft tissue injury, frostbite injury, soft tissue infections, or immune reactions (e.g., toxic epidermal necrolysis). Analysis of the “other” admissions identified a decrease in the number of electrical injuries over time using a univariable logarithmic regression ($r^2 = 0.73$) and a linear increase in the number of soft tissue infections / immune reaction ($r^2 = 0.75$). Inhalation injury was seen in 177 children (3.1% of burn admissions) and was always associated with a flame mechanism. Of the patients presenting with a flame mechanism, 10.4% had an associated inhalation injury. Inhalation injury was typically diagnosed clinically, as only 3.5% of children with a flame mechanism and 23.7% with an inhalation injury underwent bronchoscopy.

There has been little change in the ethnic/racial proportions of pediatric burn admissions to Parkland with about 42% Caucasian, 31% Hispanic, 24% African American, and 3% other. The proportion of Hispanic patients admitted has increased slightly by about 0.5% per year since 1990 ($r^2 = 0.46$), but the incidence of injuries among Hispanic children in North Texas over the 35 year period has actually decreased linearly by 0.26 admissions per 100,000 children per year ($r^2 = 0.55$). Similarly, the incidence of burn admissions among African American children has also decreased by 0.16 injuries per 100,000 per year with a loose linear correlation ($r^2 = 0.35$) (Fig. 5).

Roughly one-third (33.8%) of pediatric burn admissions were female. There was

no significant change in the gender ratio of burn admissions over the 35 years. We found the gender ratio was significantly dependent on the cause of burn (χ^2 (6, N=5,748) = 145.4, $p < 0.001$): boys were more likely to sustain electrical and flame burns (3.5 and 3.3 times the rate seen in females), but scald injuries were only 1.5 times more common among boys (Table 1).

The average age of children sustaining burn injuries has not changed over time. However, median age does vary significantly with the mechanism of injury (ANOVA on Ranks, $p < 0.001$). Older children are more likely to sustain flame and electrical burns at 9.5 (4, 14 [IQR]) and 7 years (2, 14.5 [IQR]) respectively; while younger children more frequently sustain scald at 1.7 years (1, 3 [IQR]) and contact injuries at 1.6 years (1, 3 [IQR]) (Fig. 6).

Patients with suspected non-accidental injuries were defined as a documented CPS referral, documented signs of physical abuse, concern for neglect, or discharge to foster care. Within this group of patients ($n = 403$ [7%]), there was a significant difference in mechanism of injury compared to all Parkland burn admissions (χ^2 , $p < 0.001$). This population had a significantly higher percentage of scald burns (78%) and a lower percentage of flame (11%) and contact injuries (7%). Patients with suspected non-accidental injuries had a significantly higher percentage of mortality compared to patients without documented indications of abuse (5.2% vs. 2.3%, $p < 0.001$). Further evaluation of injury mechanism in patients with concern for abuse identified a ten-fold increase in mortality of scald burns (5.7% vs. 0.5%, $p < 0.001$).

Among all 5,959 pediatric patients admitted to the Parkland Burn Center, there were 163 recorded deaths (2.7%) during or after hospitalization. Of the 5,748 children admitted for a thermal injury, the mortality rate was similar at 2.5% (146 deaths); 139 of these deaths (95%) occurred in hospital, with a minority occurring after discharge.

Among the 139 children who died during their initial hospitalization, 49 (35.3%) died within the first 24 hours; the remaining 90 mortalities occurred over a range of 2 to 205 days, with 75% occurring within 15 days of the injury. Early deaths were due primarily to shock or respiratory failure associated with an inhalational injury, while deaths occurring between 2 and 15 days after burn tended to be due to sepsis or pulmonary complications. Age less than four years was associated with an increased risk of mortality for medium-sized burns defined as 30% to 59.9% TBSA (13.7% vs. 5.9%, $p=0.009$), but not for burns under 30% TBSA (0.6% vs. 0.5%, $p=0.829$) or larger than 60% TBSA (59.3% vs. 57.1%, $p=0.958$) when compared to ages 4 to 18 years.

The revised Baux score was calculated for all patients admitted with burn, with patients then divided into two groups, those with rBaux scores less than 75 and those with scores ranging from 75 to 130. The trends in mortality over time were evaluated. While there was no significant change in mortality among children with an rBaux score less than 75, there was a significant downward trend among the group with higher rBaux scores (χ^2 (6, $N = 111$) = 13.87, $p < 0.05$) (Table 2). Date of admission significantly impacted the unadjusted mortality as well as the mortality occurring 24 hours after injury (χ^2 , $p < 0.001$, Fig. 7).

Multivariable logistic regression analysis was performed to identify predictors of mortality in pediatric burn admissions. The logistic regression model was statistically significant (χ^2 (6) = 1949, $p < 0.0001$). The model explained 55.4% (Nagelkerke's R^2) of the variance in mortality and correctly classified 98.1% of cases with a sensitivity of 44.8% and a specificity of 99.5%. As expected, the size of burn was significantly correlated with the risk of mortality with a 1.08 increase in the odds of mortality per percent TBSA. Patients with inhalation injury were 13.6 times more likely to die. Patients with suspected non-accidental injuries, as suggested by a CPS referral, documented

signs of physical abuse, or discharge to foster care, had a three-fold increase in the risk of mortality. The year of injury was negatively correlated with mortality. We did not identify a relationship between age (as a continuous variable) or flame injury and mortality in this multivariable analysis. (Table 3)

Discussion

This paper represents the largest report on a pediatric burn population managed in a single institution over an extended period of time, as well as the largest report to date on a Hispanic population. In-state admissions comprise over 98% of our patients creating the unique opportunity to compare changes in the demographics of burn center admissions to the changing demographics of the surrounding North Texas region. Although our rate of annual admission has increased, it has not kept pace with the increasing population size of the North Texas area, and thus we believe that the annual incidence of pediatric thermal injuries is actually decreasing. The decreased incidence might also be due in part to improved safety standards over the last several decades and many community education programs. Improved safety standards could specifically account for the decrease in electrical injuries over time. There has also been a relative decrease in the incidence of burn injuries among Hispanic and African American children.

The average burn size has decreased over time, and therefore more children can be successfully managed with a short stay admission (less than 2 days). This trend is similar to that noted by Engrav et al. in a longitudinal analysis of burn patients admitted to Harborview Medical Center and, we suspect, is reflective of national trends as well [5]. Although, this trend is not entirely accounted for by a decrease in overall burn size, we noted a significant drop in the length of stay per TBSA over the 35 years. This is likely reflective of a shift towards more aggressive outpatient management.

As in other epidemiological burn studies, the most common indication for admission among pediatric patients is a scald burn, followed by flame and contact injuries [5,6]. We found no change in these major mechanisms of burn over time. Similar to Morrow et al., we identified that scald burns tended to occur in younger children whereas flame injury was more common in older children [7]. Contact and scald burns in general tended to be associated with a lower risk of mortality; however, when sustained as a result of non-accidental trauma, they resulted in a higher risk of mortality, which is similarly reported in other reviews of abuse [8]. Although the cause of this paradox is unclear based on our data, we suspect that it might be due to other non-accidental injuries, the effects of parental neglect prior to the injury, or the more extensive injuries that are sustained in cases of intentional injury [8,9]. It is important to note that this analysis included all patients with concern for abuse or neglect rather than proven cases of non-accidental trauma.

Over the 35 years of the study period, the mortality rate following a thermal injury among children admitted to Parkland was low at 2.5%; although this is higher than reported in several recent analyses of a pediatric subset of the National Burn Repository, which found rates of less than 1% [6,10]. However, we did see a significant decrease in mortality over time, with the rate approaching 1% in the last 5 years of analysis. This decrease in mortality over the 35-year period is likely due to a number of factors. As discussed above, burn size has been steadily declining, and many studies have shown that burn size and patient biology are the major drivers of mortality [3,7].

Similar to the findings of Morrow et al., we did find an increased risk of mortality among children under the age of 4 who sustained burn sizes between 30% and 60% TBSA [7]. Hodgman et al. identified a similar trend in a recent analysis of the National Burn Repository [10]. However, this trend was not consistent for patients with small and large burns. We did not see a significant relationship between age as a continuous

variable and mortality on multivariable logistic regression. Sheridan et al. reported no difference in mortality between children less than 4 years compared to children greater than 4 years old; however, they excluded deaths and anoxic brain injury within 24 hours of injury and reported a very low mortality rate [11]. Differences in inclusion criteria are a possible explanation of differences between studies on mortality associated with age.

We chose to evaluate our mortality rates over time by group based on rBaux score because our large database does not contain the detailed data points to collect the PRISM score, a score specific to pediatric patients [12]. It is important to note that Osler et al. recommended the rBaux score as the best predictor of mortality for patients between ages 20 and 80 with larger burns [4]. However, Dokter et al. externally validated the rBaux score and found an improved AUROC with inclusion of all ages compared to only evaluating the 20 to 80 year range with large burns [3]. While a pediatric Baux (P-Baux) score has been developed, it has yet to be externally validated on a pediatric population greater than 200 patients [13,14]. For these reasons, we used the rBaux score. When we applied the rBaux score to our population, we found that the mortality associated with scores over 75 decreased over time; however, there was no change seen in children with an rBaux score less than 75, likely owing to the already low likelihood of mortality in that group seen in our population and that of Karimi et al. [13].

The etiology of improvements in pediatric mortality rate and length of stay per TBSA burn are multifactorial. We believe that this finding is reflective of the evolution of modern critical care techniques and burn care. Early excision, adequate resuscitation, early enteral nutrition, appropriate blood glucose control, early and aggressive source control in sepsis, improvements in antibiotics, lung protective ventilator strategies, restrictive transfusion strategies, as well as early rehabilitation are all factors that likely contribute to our improvements in outcomes over 35 years.

It is important to keep in mind that our findings are based on retrospective observational

analysis. This dataset represents only the inpatient pediatric admissions to the Parkland Burn Center and therefore does not account for the large subset of patients initially seen in the emergency room and further managed as outpatients or referred only to the outpatient clinic. We are therefore unable to include these patients in the analysis of burn mechanism and incidence in North Texas. Furthermore, it is possible that a significant shift toward outpatient management over the 35 years could account for the perceived decline in burn incidence. However, there is still a significant decrease in the overall size of burns, the length of hospitalization adjusted to burn size, the overall mortality, and the adjusted mortality over time in the pediatric burn population admitted to the Parkland Burn Center.

Acknowledgments

We would like to acknowledge Mary Wallace for her technical writing assistance.

Research reported in this publication was supported by the National Institute for General Sciences of the National Institutes of Health under award number T32GM008593; and the United States Army Medical Research Administration, TATRC, Department of Defense grant number W81XWH-12-2-0074-01.

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Legend

Figure 1. North Texas incidence of burn admissions per 100,000 over time. Short stay is defined as 1-2 days in the hospital. There was a decrease in burn admissions over time and an increase in short stays over time ($r^2 = 0.51$ and 0.79 , respectively).

Figure 2. Burn severity over time and length of stay over time. Represented as first (25%), second (50%), and third (75%) quartile of the percent total body surface area burn (TBSA) and length of stay (LOS) over time. There was a linear decrease in the second and third quartile of burn size over time ($r^2 = 0.41$ and 0.62 , respectively). The median LOS has been decreasing over time ($r^2 = 0.75$).

Figure 3. Length of stay per percentile of total body surface area burn (TBSA) over time. First (25%), second (median), and third (75%) quartile of length of stay in hospital days normalized to burn size. The median length of stay normalized to burn size has been decreasing over time ($r^2 = 0.77$).

Figure 4. Cause of all admissions to Parkland Burn Unit over time. Number of admissions per cause reported per year.

Figure 5. Incidence of burn admissions by race/ethnicity reported as event per 100,000 for the relevant population by year. There was a decrease in the incidence among the Hispanic and African American population ($r^2 = 0.55$ and 0.35 , respectively).

Figure 6. Cause of burn by age. Reported as median age in years with interquartile range. There was a significant difference between groups (ANOVA on Ranks, $p < 0.001$).

Figure 7. Percent mortality over time. Reported in 5-year increments as percent mortality within the first 24 hours and mortality after the initial 24 hours. The unadjusted mortality as well as the mortality occurring 24 hours after injury was dependent on the hemi-decade of admission (χ^2 , $p < 0.001$).

Figure 1.

Figure 1.

Figure 2.

Figure 2.

Figure 3.

Figure 3.

Figure 4.

Figure 4.

Figure 5.

Figure 5.

Figure 6.

Figure 6.

Figure 7.

Figure 7.

Table 1. Cause of burn by gender

Cause	Female (%)	Male (%)	Odds Ratio (M:F)
Scald	40.04	59.96	1.50
Flame	23.33	76.67	3.29
Contact	36.16	63.84	1.77
Grease	36.48	63.52	1.74
Unknown	39.50	60.50	1.53
Electrical	21.97	78.03	3.55
Chemical	39.29	60.71	1.55

Gender reported as percentage. Male to female odds ratio (M:F) was dependent on the cause of burn (Chi-square = 145.392 with 6 degrees of freedom, $p < 0.001$).

Table 2. rBaux score compared to observed mortality

Year	rBaux<75 (<5% predicted mortality)			rBaux 75-130 (5-78% predicted mortality)		
	All	Mortality	% Mortality*	All	Mortality	% Mortality†
1974-79	844	14	1.7	26	20	76.9
1980-84	731	13	1.8	16	12	75.0
1985-89	667	14	2.1	24	17	70.8
1990-94	741	7	0.9	10	3	30.0
1995-99	939	10	1.1	12	5	41.7
2000-04	757	6	0.8	14	6	42.9
2005-09	836	8	1.0	9	4	44.4

rBaux score was used to compare predicted mortality to actual mortality over 5 year increments. Mortality was not dependent on time in rBaux scores less than 75.

* = (Chi-square = 8.849 with 6 degrees of freedom, p = 0.182).

The percent observed mortality was significantly dependent on hemi-decade in rBaux scores 75 to 130.

† = (Chi-square = 13.865 with 6 degrees of freedom, p = 0.031).

Table 3. Predictors of mortality

Factor	β coefficient	p-value	OR (95% C.I.)
TBSA	0.075	<0.0001	1.08 (1.07-1.09)
Abuse	1.112	<0.0001	3.04 (1.58-5.85)
Inhalation	2.609	<0.0001	13.59 (7.2-25.4)
Year	-0.033	0.006	0.97 (0.95-0.99)
Age	-0.011	0.63	0.99 (0.94-1.04)
Flame	0.114	0.74	1.12 (0.58-2.17)

Multivariable logistic regression of factors predicting mortality. Odds ratio (OR) reported with 95% confidence interval. TBSA = total body surface area burn. Abuse = potential for abuse with concerning patterns of injury, documented CPS referral, or documented discharge to foster care. Flame was compared to all other causes of burn.