Mortality Associated With Injuries Sustained By Aircraft Accident Burn Survivors

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Abstract

INTRODUCTION: Air travel is one of the most popular and efficient means of transportation available today. Although infrequent, disasters involving aircraft are an unfortunate reality. The medical profession is still learning how to best care for air crash survivors. The purpose of this paper is to identify the survivability of aircraft accidents as well as characterize morbidity and mortality of associated injuries sustained by aircraft accident burn survivors admitted to a major burn center over a 40-year period.METHODS: We performed a retrospective chart review of all aircraft accident patients admitted to our institution from January 1955 through July 1997. Data collected included age, gender, total body surface area burned (TBSA), full thickness burn, inhalation injury and associated injuries sustained at time of mishap. As major advances in burn care were achieved after 1975, patients injured prior to January 1975 were placed in group A (N=363); the remainder was placed in group B (N=143). Mortality was reviewed between the two different time periods for full thickness burns using Logistic Regression and Chi-squared method of analysis.RESULTS: During the study period there were 30,718 aircraft accidents tracked by the NTSB. Of these, 19.33% (N=5,939) involved at least one fatality. Of 9175 patients admitted to the U. S. Army Burn center between January 1955 and July 1997, 506 (5.5%) were involved in aircraft crashes. The patient population was 92.3% male (N=467) and 7.7% female (N=23). The average age was 28.7 years. The overall mean TBSA was 32.5% and the full thickness burn was 19.05%. Associated injuries were seen in 77.0% of admissions. Fractures occurred in 39.72% of admissions, while closed head injuries were sustained by 8.1%. Inhalation injury was observed in 25.4% of patients; eye injuries in 7.5%. Hemo/pneumothorax, spleen, and liver injuries were seen in less than 3%. There was a dramatic improvement in mortality (p<.001) in our population with burn size >40% between the two periods. In patients with less than 40% TBSAA, however, associated closed head injuries and fractures were associated with a 350% higher mortality (p<.001). CONCLUSIONS: Less than 20% of aircraft accidents involve a fatality. Most thermally injured survivors of aircraft crashes, 77.0%, are associated with significant blunt injury. Despite a statistically significant decrease in overall mortality of burn patients, closed head injuries and fractures are associated with increased mortality when compared to similarly burned patients without these injuries. A multi-disciplinary, well-coordinated team approach is necessary to optimize the treatment to this sub group of patients.

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“The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.”

INTRODUCTION

Although infrequent, aircraft disasters are an unfortunate reality. High speed and altitude as well as passenger capacity are distinguishing characteristics of air travel compared to other forms of mass transportation. These features have always posed the highest risk of severe injuries and fatalities from an accident. This difference became all too painfully clear when passengers began air travel in significant volumes in the 1920’s.

In April 1967, Congress formed the National Transportation Safety Board (NTSB) to study aircraft accidents [1] The NTSB has maintained the Aviation Accident Database that tracks aircraft accidents from 1962 to present day. From 1962 to 1997, there have been 130,000 accidents involving aircraft with an average of 2250 aircraft accidents per year [1] During the time period of our study, there were 30,718 airplane accidents alone with 5,939 involving at least one fatality.

Assuming that each air crash involved only 1 passenger, the fatality rate for our study period is 19.33%. The exact number of passenger per aircraft per accident in unknown as there currently exists no such database.

During our review, it was noted that the proportion of aircraft accidents, in all phases of flight, involving fatalities has consistently remained near 20% {Figure 1}. From 1990-2000 there were 19,225 airplane accidents with 3,811 involving fatalities for a fatality rate of 19.82%. In 1998 alone there were 1870 crashes with 370 (19.78%) of them involving fatalities. Even if we assume that every other non-fatal crash in 1998 carried only a solitary pilot, the fatality rate for 1998 is 25.4%. While actual statistics are unknown, it would seem reasonable to assume that 80% of the average aircraft accidents have no fatalities.

The actual number of people killed as a result of airplane accidents in 1998 is 475. In contrast, there were 41,471 fatal automobile crashes in 1998. There were 1.6 fatalities per 100 million miles traveled on our nation's highways. Meanwhile, there were 0.021 fatalities per 100,000 flight hours in 1998 and 0.032 fatalities per 100,000 departures, for all comers [1] .

The medical profession is still learning how to best care for these air crash survivors. The purpose of this study is to identify the change in mortality associated with injuries sustained by aircraft accident burn survivors admitted to a major burn center over a 40-year period.

METHODS & MATERIALS

We performed a retrospective chart review of all aircraft accident patients admitted to our institution from January 1955 through July 1997 (N=506). We reviewed age, gender, total body surface area burned (TBSA), full thickness burn (FTB), inhalation injury, and associated injuries sustained at time of mishap. As major advances in the care of thermally injured patients to including early excision and grafting of burns, interdisciplinary burn-team rounds including surgeons, respiratory, occupational and physical therapists, dieticians and social workers, and the alternating use of topical antibiotics were implemented after 1974, patients injured prior to January 1975 were placed in group A (N=363) and the remainder were placed in group B (N=143) [234] . Mortality was reviewed between the two different time periods for total body surface area burned as well as full thickness burns. Logistic regression and Chi-Square method of statistical analysis was used to determine significant differences in associated injury and mortality.

RESULTS

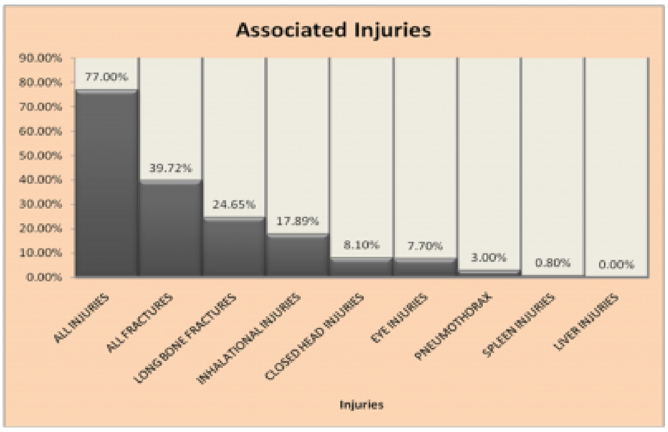
Of 9175 patients admitted to the U. S. Army Burn Center between January 1955 and July 1997, 5.51% (N=506) were involved in aircraft crashes. The patient population was 92.3% male (N=467) and 7.7% female (N=39). The average age was 28.7 years. There was no statistically significant difference in the nature or extent of injuries sustained by passengers of military vs. civilian aircraft (P=0.247). Likewise, there was no difference in between the commercial vs. private aircraft other than the number of passengers involved. All of our accidents occurred on land.

Figure 1


Dallas Times Herald
Miraculously, 94 survive
13 die in fiery Delta crash – search for clues begins

The overall mean TBSA was 32.5%. The mean body surface area sustaining FTB was 19.05%. Inhalation injury was observed in 17.89% of patients and associated injuries were seen in 42.5%. Closed head injuries were sustained by 8.1%, eye injuries by 7.7%, hemo/pneumothorax, spleen, and liver injuries combined were seen in less than 4% of the sample population. Fractures occurred in 39.72% of admissions. {Figure 2} There was no difference in the distribution of injuries between groups (P=0.36).

Figure 2



Corresponding with the vast advances in burn care, we observed a tremendous decline in mortality between the two groups. Linear regression analysis identified TBSA (P<0.0001; Odds Ratio 0.902) and group (P<0.0001, Odds Ratio 23.047) as the only associated factors affecting mortality. {Figure 3} The mortality rate for patients with FTB 20% across all groups was 16% (P<0.99). For FTB 40% the morality decreased from 35% to 21.8% but was not statistically significant (P<0.29). However, for FTB 60% there was a dramatic decline in mortality from 78.6% to 18.8% (P<0.001). For FTB < 60% there was no significant change in mortality, as these patients did uniformly poorly. {Figure 4}

Figure 3

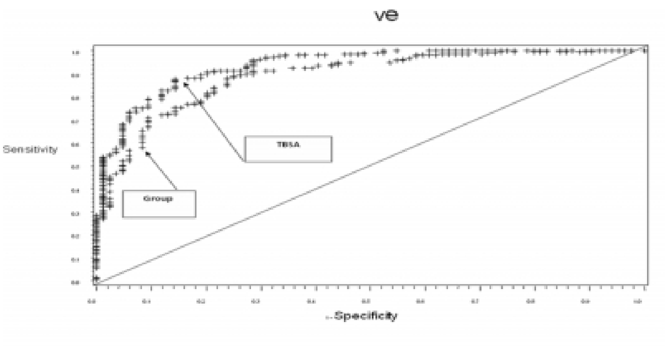


Figure 3. Roc Curve of total body surface area (TBSA) and study group vs. mortality. Area under the curve = 0.935.

Figure 4

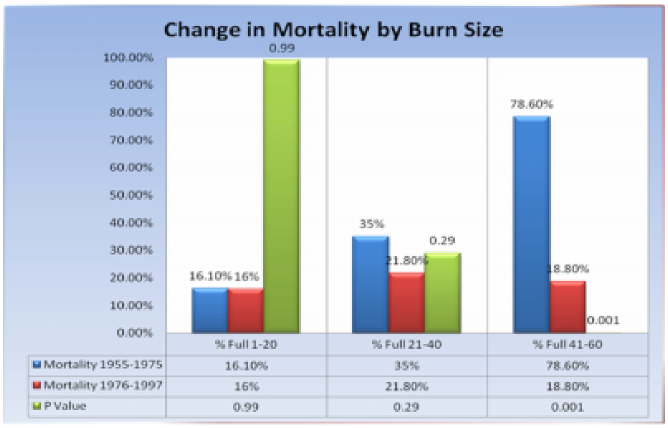


Figure 4. Table depicting the change in mortality among the burn size sub-groups

While there was no statistically significant decrease in mortality for patients with less than 40% TBSA burns, there was a 370% increase in mortality if these burns were associated with closed head injuries over time (P<0.001). There was a 350% increase in mortality over time for the same patients if they concomitantly sustained at least one significant fracture (P<0.001). For purposes of this study, significant fractures were limited to femur, pelvis, tibia, spine, and humerus. There were no statistically significant differences in the distribution of fractures between the two study groups. {Figure 5}

Figure 5

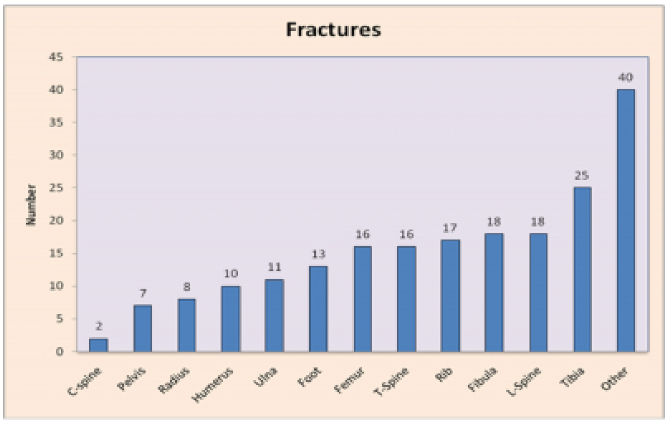


Figure 5. Breakdown of observed fractures. Significant fractures were defined as fractures to the femur, tibia, humerus, pelvis, spine or any foot fracture limiting ambulation. Other fractures include hand and facial fractures.

DISCUSSION

Since the threat of nuclear war stimulated the interest in thermal injuries in the 1950's, care of the thermally injured patient has dramatically improved. [5] The use of topical and systemic anti-microbial therapy increased once it was learned that bacterially derived toxins lead to overwhelming sepsis and death [2367891011] . Deaths from acute renal failure dropped off once adequate fluid resuscitation protocols were in place [271213] . Even local burn wound management has progressed since the dawn of the atomic age [2379121415] .

There was indeed a dramatic improvement in mortality in our population with burn size greater than 40% between the two periods. The mortality rate of our patient population was 78.6% for patients sustaining at least 40% TBSA in group A; that number dramatically decreased to 18.8% for group B (p<0.001). There was no statistically significant difference in the mortality rate for patients sustaining less than 20% TBSA (P<0.299). However, in the TBSA population, mortality was at least 350% higher than observed in a similarly burned patient without an associated significant fracture or a closed head injury (p<0.001).

Significant fractures were observed in nearly a quarter of our patients (24.65%), while less than a tenth (8.1%) of these patients had sustained closed head injuries {Figure 2}. Given both the altitude and speed of aircraft, it is not hard to understand why air crash survivors who are burned while sustaining a high-energy head injury would do poorly. The most commonly observed fractures were fractures to the thoraco-lumbar spine (16.9%) followed closely by fractures to the tibia (12.5%), femur (7.9%), and foot (6.4%). Pelvic fractures were seen in only 3.4% of all fractures {Figure 5}.

The vast majority of these fractures were treated by the general or burn surgeon with splinting or casting. Only 4 patients in our study received operative treatment for their significant fractures. It is generally accepted today that early operative intervention of fractures aids in mobilization and hygiene, greatly aids rehabilitation, as well as reduce the co-morbidities associated with orthopedic injuries [16171819202122] . Bone and colleagues demonstrated the benefit of reduced mortality with early operative fixation of long bone fractures in the multiply injured patient [16171819] . Bone demonstrated that early operative fixation of femur fractures greatly reduced pulmonary complications. Harris followed this with his study demonstrating that early surgical fixation of femur fractures in burn patients significantly reduces pulmonary complications [1620] .

Early operative fixation of the humerus allows for greater use of the extremity to assist with hygiene, nursing care, transfers, as well as ambulation with crutches [23] . Tscherne proposes the priority for operative fixation of the poly-trauma patient with multiple fractures as follows: (1) tibia, (2) femur, (3) pelvis, (4) spine, (5) upper extremity [24] . Considering that less than 3% of our patient population sustained any blunt thoraco-abdominal trauma, while nearly 25% sustained long bone fractures, it seems reasonable that the increased mortality in these multiply injured patients is, in part, related to the period of immobilization without definitive fixation of extremity fractures.

Some key points not directly addressed in our study are the safety and appropriate timing of surgery in the burned patient. When is the optimal time to operate through burned tissue? Should formal open reduction and internal fixation or even external fixation be attempted through burned tissue?

The works of Teplitz does support that the burned skin is not colonized until 48 hours post burn [2526] . Many authors have interpreted this data to mean that that surgery, especially orthopedic surgery, within the first 48 hours after burn is safe. Indeed, Saffle reported the results of 42 fractures in 22 patients admitted to their burn center over a 5-year period [25] . He reported that all but one fracture healed satisfactorily if treated within 48 hours. Grisola and Peltier used an animal model to treat femur fractures with open reduction and internal fixation through overlying burn tissue and reported a 10% incidence of infectious complications if the procedure was performed within 24 hrs [27] . If the procedure was performed within 48 hours they report an 86% healing rate.

Dossett and colleagues reported a series of 28 patients with 34 fractures complicating burns, which were treated with operative orthopedic intervention within 24 hours of injury [28] . 13 fractures were treated with intramedullary nailing and 15 were treated with open reduction and internal fixation. When burns were over the fracture or operative site, the incisions were made through the burns. The authors reported that with mean follow up of 53 months, only 1 fracture failed to heal. These studies, and studies like these, have been used to support the argument for early operative intervention of fractures in burn patients within the first 48 hours of injury.

However, Dr. Pruitt, commenting on Dr. Dossett's work, points out that while he has had similar results, neither work was a prospective, randomized study [28] . Additionally, he points out that operating within the first 48 hours may compete with the need to adequately resuscitate the burn patient as the anesthetic agent "may ablate the cardiovascular compensatory responses to hypovolemia." [28]

Additionally, Teplitz, in the same study cited by many as the basis for operative intervention within 48 hours, points out that by the 4 [[[th]]] -5 [[[th]]] day "bacilli have invaded to the junction of the burned and viable tissue and at this time a low grade bacteremia becomes evident. Bacteria then invade to the zone of viable granulation tissue." [2629] Incisions through this tissue would seem to provide a conduit for these bacteria to indwelling metal implants. A follow on study by Teplitz and Moncrief confirmed these findings and showed that the burn wound showed an increase susceptibility to hematogenous infection. [29] This further raises the concern of hematogenous seeding of indwelling hardware. In terms of treatment of weight bearing long bones with intramedullary nailing, Bucholz and Brumback state that fractures with extensive necrosis of the overlying soft tissue (as would be expected in burned patients) carry and unacceptable level of risk for infection after intramedullary nailing and should be avoided regardless of the treatment method. [30] Artz and Moncrief bluntly state that open reduction to fractures should never be performed in acute burns. [31]

Finally, Artz, Moncrief and Pruitt stated it best -- "Although open reduction and fractures have been carried out without significant complication when performed within the first 48 hours following burn injury, such procedures should be avoided, since the burn wound is invariably contaminated, the bacterial population increases in density with post-burn time, and the frequency of septicemia and bacteremia places operative wounds and implanted foreign bodies at great risk to infection." [32]

The literature is clear enough on the definite benefits to operative stabilization of fractures to goal of maximum post-injury rehabilitation. This is congruent with the multi-disciplinary team approach to modern day burn therapy. Further research with prospective, randomized studies, as advocated by Dr. Pruitt, is necessary to clearly establish the optimum time and technique for orthopedic surgical intervention in burn patients.

Also, our study population is unique in that it includes military accidents. Our burn center is equipped with a rapid response air-evacuation team that can retrieve burned patients from all over the world in less than 24 hours. This may not be feasible for all civilian burn centers, and may lend a bias to our data. As this database was formed using a chart review of the survivors, no data was collected on the cause of death in the non-survivors. Likewise, we do not have the data on the airspeed at time of incident, factors leading to the accident.

CONCLUSIONS

While one of the most efficient and popular means of transportation available today, air travel is not without its mishaps. Due to the speed, altitude, and passenger capacity of most aircraft, as well as the highly volatile fuel, we can expect significant injuries from these unfortunate survivors. While air crash fatalities attract the bulk of the attention, the fact remains that the vast majority of passengers involved in aircraft accidents do survive. While no authoritative database exists to definitively study the actual fatality rate of airplane accidents, our data suggests that at least 80% of airplane accidents do not involve fatalities.

The literature does support that the burned skin is not colonized until 48 hours post burn. After 48 hours most authors recommend a delay in surgery other than external fixation for orthopedic injuries. While theoretically it is feasible to place indwelling hardware through burned tissue, there exist no good literature to support this practice in humans. For this reason, we advocate further research in this area.

Most (77.0%) thermally injured survivors of aircraft crashes also sustain significant blunt injury. Closed head injuries and fractures are associated with increased mortality as compared to similarly burned patients without these injuries. While the overall management of trauma and especially burn care is the terrain of the general surgeon, our data would suggest that the orthopedic surgeon has an especially pressing role in the management of multiply injured air crash burn survivors.

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