Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.JournalofSurgicalResearch.com

Injury and fatality risks in aeromedical transport: focus on prevention

Heidi H. Hon, MD,[a] Thomas R. Wojda, MD,[a,b] Noran Barry, MD,[a] Ulunna MacBean, MD,[a] John P. Anagnostakos, MD,[c] David C. Evans, MD,[d] Peter G. Thomas, DO,[a,e] and Stanislaw P. Stawicki, MD[a,b,e,*]

[a] Department of Surgery, St. Luke's University Health Network, Bethlehem, Pennsylvania
[b] Department of Research & Innovation, St. Luke's University Health Network, Bethlehem, Pennsylvania
[c] Temple University School of Medicine, St. Luke's University Hospital Campus, Bethlehem, Pennsylvania
[d] Department of Surgery, The Ohio State University College of Medicine, Columbus, Ohio
[e] Regional I Trauma Center, St. Luke's University Health Network, Bethlehem, Pennsylvania

ARTICLE INFO

Article history:
Received 8 December 2015
Received in revised form
25 April 2016
Accepted 3 May 2016
Available online 10 May 2016

Keywords:
Aeromedical transportation
Aircraft crash
Injury risk
Mortality risk
Transportation safety

ABSTRACT

Background: Aeromedical transport (AMT) is a reliable and well-established life-saving option for rapid patient transfers to health care delivery hubs. However, owing to the very nature of AMT, fatal and nonfatal events may occur. This study reviews aeromedical incidents reported since the publication of the last definitive review in 2003, aiming to provide additional insight into a wide range of factors potentially associated with fatal and nonfatal AMT incidents (AMTIs). We hypothesized that weather and/or visual conditions, postcrash fire, aircraft make and/or type, and time of day all correlate with the risk of AMTI with injury or fatality.

Methods: Specialty databases were queried for AMTI between January 1, 2003 and July 31, 2015. Additional Internet-based resources were also used to find any additional AMTI (including non-US occurrences) to augment the event sample size available for analysis. Univariate analyses of the collected sample were then performed for association between "fatal crash or injury" (FCOI) and weather/visual conditions, aircraft type and/or make, pilot error, equipment failure, post-incident fire, time of day (6 am-7 pm *versus* 7 pm-6 am), weekend (Friday-Sunday) *versus* weekday (Monday-Thursday), season of the year, and presence of patient on board. Variables reaching significance level of $P < 0.20$ were included in multivariate analysis.

Results: A total of 59 AMTIs were identified. Helicopters were involved in 52 of 59 AMTIs, with 7 of 59 fixed-wing incidents. Comparing pre-2003 data with post-2003 data, we noted a significant decrease in AMTIs per month (0.70 *versus* 0.39, respectively, $P = 0.048$), whereas the number of fatalities per year increased slightly (7.20 *versus* 8.26, p = n/s). In univariate analyses, abnormal weather conditions, impaired visibility, time of incident (7 pm-6 am), aircraft model/make, and post-incident fire all reached statistical significance sufficient for inclusion in multivariate analysis ($P < 0.20$). Factors independently associated with FCOI included post-incident fire (odds ratio, 19.0; 95% confidence interval, 1.41-255.5) and time of incident between 7 pm and 6 am (odds ratio, 11.2; 95% confidence interval, 1.29-97.2).

AAS/SUS Statement: This project was presented at the 11th Annual Academic Surgical Congress, Jacksonville, Florida, February 2-4, 2016.

* *Corresponding author*. Department of Research & Innovation, St. Luke's University Health Network, EW2-Research Administration, 801 Ostrum Street, Bethlehem, PA 18015. Tel.: +1 484 526 4646; fax: +1 484 526 3583.
E-mail address: stanislaw.stawicki@sluhn.org (S.P. Stawicki).

http://dx.doi.org/10.1016/j.jss.2016.05.003

Weather conditions, impaired visibility, and aircraft model/make were not independently associated with FCOI.

Conclusions: The present study supports previous observation that post-crash fire is independently associated with FCOI. However, our data do not support previous observations that weather conditions, impaired visibility, or aircraft model/make are independently predictive of fatal AMTI. In addition, this report demonstrates that flights between the hours of 7 pm-6 am may be associated with greater odds of FCOI. Efforts directed at identification, remediation, and active prevention of factors associated with AMTI and FCOI are warranted given the global increase in aeromedical transport.

Introduction

Aeromedical transport (AMT) is a well-established and reliable option for life-saving medical transfers between health care delivery hubs. As health care systems continue to evolve around the globe, the need for patient-centered transportation delivery platforms is increasing, within and between rapidly consolidating health networks. Consequently, the usage of AMT is also likely to increase.[1,2] In 1991, approximately 162,000 flight hours were reported by Emergency Medical Services AMT personnel.[1] This number has nearly doubled by 2005, with an estimated 300,000 flight hours reported by the National Transportation Safety Board (NTSB).[1] The Association of Air Medical Services estimates that 400,000 patients annually undergo AMT in the United States alone.[2] Inherent to such high volume of flights is the elevated baseline risk of both fatal and nonfatal AMT-related incidents (AMTI).[3]

In the United States, after an approximate doubling of helicopters dedicated to AMT before 1995, the number of aircraft providing AMT services grew by 130% between 1995 and 2008.[2] Globally, similar trends have been observed in AMT activity.[4-7] As aeromedical transport becomes part of the global mainstream, we must remember that accident rates of 0.56-0.73 per 10,000 missions have been documented, with fatal AMTI rates between 0.04-0.23 per 10,000.[4] Moreover, fatal incidents may be more likely to occur in AMT than in general aviation.[8,9] As the upward trend in AMT volume continues, both industry experts and the NTSB are calling for proactive stance on solving key safety issues.[1,2,10]

Previous studies demonstrated that post-crash fire, impaired visual and weather conditions, darkness, aircraft make/type, and pilot error may be associated with greater odds of fatal AMTI.[8,11] Since the mid-2000's, various safety initiatives were introduced to enhance AMT safety.[1,2] Consequently, we felt that a reappraisal of AMTI following the last definitive review on the topic in 2003 was warranted, especially in the context of the abovementioned safety initiatives and wider incorporation of key technological advancements and safety measures across the industry.[1,2,11,12] The aim of this study was to review all reported AMTI since 2003, focusing on risk factors for fatal crash or injury (FCOI) in the context of incident prevention and mortality reduction. We hypothesized that (1) the number of crashes and fatalities has declined as a result of new safety initiatives and (2) that weather and/or visual conditions, post-crash fire, aircraft make/type, and time of day correlate with the risk of FCOI.

Methods

A retrospective review of AMTI was conducted using previously compiled repositories of aeromedical incidents between 2003-2012[13] and 2013-2014,[14] various specialty databases (e.g., NTSB) and Internet resources.[15-18] Web-based resources were used to find additional AMTI (including non-US occurrences) to augment the event sample size available for analysis.[13,14,19-22] The final data set contains all reported AMTI between January 1, 2003 and July 31, 2015.

The data set assembled for the purposes of this study incorporates the following variables for each reported AMTI: season of year, incident month, day of week (weekend defined as Friday, Saturday, and Sunday), time of day (local time, 6 am-7 pm *versus* 7 pm-6 am), the type/model of aircraft involved, and occupant characteristics (e.g., role description, number on board, injury, and fatality information). Other crash-specific factors we also recorded, including visibility conditions, equipment failure, pilot error, weather conditions, and postincident fire. Although a broad range of additional data points was provided, this information was not uniformly reported across various sources and we elected not to include such incomplete data in the current analysis.

Descriptive analyses of the collected data set of 59 AMTI were performed using the following parameters: number of AMTI per unit time (y/mo); raw number of injuries and fatalities; monthly injury and fatality rates; fatalities and injuries per crash; frequency of AMTI by month; and detailed occurrence-specific characteristics (e.g., incident causes, timing relative to flight phase, general types of crash/impact). Descriptive results were then compared to historical data from previous reports.[11,12,23]

Our primary endpoint was a composite finding of post-AMTI FCOI. We estimated that to observe a 33% difference between groups as statistically significant ($\alpha < 0.05$; $[1-\beta] = 0.80$) the study required >50 AMTI, with an approximate 4:1 ratio between comparison groups. Univariate statistical analyses were performed for associations between FCOI and weather/visual conditions, aircraft type/make, pilot error, equipment failure, post-incident fire, time of day (6am-7pm *versus* 7pm-6am), time of week (weekday *versus* weekend), season of the year, and presence of patient on board. Fisher's exact test was used for categorical variables. Mann–Whitney *U* test was used for continuous data. Parameters reaching significance level of $P < 0.20$ were then included in a multivariate analysis. Results of multivariate analysis were reported as odds ratios (ORs) with corresponding 95%