 Brace for impact! A thesis on medical care following an airplane crash
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Chapter 2

February 2009 airplane crash at Amsterdam Airport Schiphol: An overview of injuries and patient distribution

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Based on:

February 2009 airplane crash at Amsterdam Schiphol airport: an overview of injuries and patient distribution.
Abstract

Objective
The objective of this study was to describe the injuries and distribution of casualties resulting from the crash of Turkish Airlines flight TK 1951 near Schiphol Airport in the Netherlands on the 25 February 2009.

Methods
This was a retrospective, descriptive study. Based on a review of the hospital records for all casualties of the airplane crash, triage at the scene, time to emergency department, Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS), mortality, length of hospital stay and surgical procedures were abstracted.

Results
Of the 135 passengers, nine died at the scene. A total of 126 survivors were examined in 15 hospitals; data for all survivors were available for the study. Median time between the crash and arrival at an emergency department was 3.5 hours (range 1.25-5.5 hours). Six passengers were uninjured and 66 were admitted to hospital. A total of 305 injuries were recorded. The majority was head and facial injuries (92), spinal injuries (35), and fractures of extremities (38). Eighteen percent of the patients had a spinal injury. The mean ISS was 6.4* (range = 1–66*). The ISS score was ≥16 for 15* patients. Surgical procedures (80) were necessary in 23 patients. There was no in-hospital mortality.

Conclusions
Although the accident was in an urban area, there was a significant delay between the time of accident and arrival of casualties at hospital emergency departments. The Turkish Airlines crash provides extensive information for research into mass-casualty or disaster management, triage, plane crash injuries, and survivability.
Introduction

On the 25 February 2009 at 10:26 hours, Turkish Airlines flight TK1951 crashed near Amsterdam Schiphol Airport, in the Netherlands, just before landing. The aircraft came to rest in a field, about 1.5 kilometres from the runway. The fuselage was torn open just in front of the wings and in front of the tail fin (vertical stabiliser) at the last row of seats, breaking the airplane into 3 sections (Figure 1). The front section with the cockpit and first seven rows was most heavily damaged. (1) Although there were initially some problems with locating the exact site of the crash, the medical response was rapid. Three helicopter trauma teams and 82 ambulances responded. Local farmers supplied agricultural machines to help evacuate the victims from the almost impassable field to the public road and the casualty clearing station.

This study describes the results of a retrospective study into the outcomes of this airplane crash. The study aims to answer several research questions: 1. How were patients distributed among the hospitals?; and 2. How many injuries and what kind of injuries were sustained by the casualties? 3. How severe were the injuries and of what type, and how were they treated?

Figure 1. Aerial view of the crashed airplane.
Methods

First, patients’ medical records were analysed retrospectively to assess how patients were distributed among different hospitals. In addition, ambulance records, emergency department records and hospital records of all survivors were analysed performed to retrieve information about: pre-hospital triage (Box 1); time between the crash and arrival at the emergency department; types and severities of injuries; surgical procedures performed; duration of hospital stay; intensive Care Unit (ICU) admittance; complications; follow-up until discharge and hospital mortality. Data were recorded in a Microsoft Access® [Microsoft, Inc., Redmond, WA] database. Hospitals are designated a trauma care level by the Dutch government, were Level I hospitals have a coordinating role in the regional trauma network. Level I hospitals are equipped with all trauma care facilities; Level II hospitals have “certain” trauma care facilities, some of which are extensive, almost to the standard of Level I hospitals; and Level-III hospitals contain basic trauma care facilities.

As is common in trauma centres, the types and severity of injuries were defined using the Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS). (2) The AIS is a standardised anatomical scoring system, in which injuries are scored on a scale from 1 to 6 for each body area: 1 = minor injury, 5 = critical injury, and 6 is lethal. The highest AIS scores are defined per body area, after which the ISS is calculated by taking an individual’s 3 highest AIS scores, and adding up the square of each of these scores; thus resulting in an ISS score between 0 and 75. (3)

Figure 2. Time from crash to arrival at ED.
Results

The aircraft carried 135 people: 128 passengers and seven crew-members. Five passengers and four of the crew died at the scene of the accident. All survivors were transported to hospitals.

Patient Distribution

After being triaged by the emergency medical personnel according to the ‘Triage Sieve and Sort’ method, and evacuated from the scene of the accident, 124 patients were transported to 14 different hospitals (Table 1). These hospitals were Level I, II, or III hospitals. Two passengers left the scene of the accident by themselves, however reported to a hospital the next day. One of them reported to a hospital outside the district where the crash occurred. With the inclusion of this hospital, a total of 15 hospitals were involved (Table 1).

The first patient arrived at the emergency department at 11:40 hours, one hour and 14 minutes after the crash. The last patient (excluding the two who reported to hospital a day later) arrived at 16:13 hours (Figure 2). All 126 survivors of the crash, 83 men and 43 women, were included in this study. The mean age was 38 years (range: 11 months–76 years). There were very few records of pre-hospital triage in most cases, and the in-hospital triage records were also missing. After admission, three patients were referred to another hospital because of their type of injury: two were upgraded from a Level II hospital to a Level I hospital, and one went from a Level III hospital to a Level I hospital. For the analysis, data for these patients were abstracted from the medical records from the second hospital where they ultimately received treatment.

Injuries

Of the 126 patients, 60 patients were discharged from the emergency department, and 66 were hospitalised for a median duration of 4 days (range: 1–104 days). Fourteen patients were admitted to an ICU, five of whom required mechanical ventilation. The mean duration of ICU stay was seven days (range: 1–59 days, median: 2). Of the 126 patients, six were physically unharmed. The remaining 120 patients had a total of 305 injuries (Figure 3), and 75 of these sustained over 2 injuries. The mean ISS score was 6.4* (range: 1–66*), 15* patients were admitted with an ISS ≥16, and therefore were considered to be “multi-traumatised”. (4) The most frequent injuries involved the head and face (92 injuries in 60 patients). These were
mainly contusions and lacerations (48 injuries in 42 patients), cerebral concussion or contusion (20 injuries in 20 patients) and/or facial fractures (20 injuries in 14 patients). There were 35 spinal injuries (33 fractures) in 23 patients, 10 of whom required surgical stabilisation of one or more fractures. Twenty patients had a total of 38 fractures of the extremities, 25 of which needed surgical treatment.

Table 1. Overview of hospitals involved and number of casualties received by each hospital

<table>
<thead>
<tr>
<th>Hospital (level I, II, III)</th>
<th>No of casualties received</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMC (I)</td>
<td>19</td>
</tr>
<tr>
<td>VU (I)</td>
<td>25</td>
</tr>
<tr>
<td>UMCU (I)</td>
<td>4 (+2)*</td>
</tr>
<tr>
<td>LUMC (I)</td>
<td>4 (+1)*</td>
</tr>
<tr>
<td>HAGA (II)</td>
<td>4</td>
</tr>
<tr>
<td>KG (II)</td>
<td>32 (-2)**</td>
</tr>
<tr>
<td>MCA (II)</td>
<td>1</td>
</tr>
<tr>
<td>WFG (II)</td>
<td>1</td>
</tr>
<tr>
<td>SLAZ (II)</td>
<td>1</td>
</tr>
<tr>
<td>RKZ (II)</td>
<td>12</td>
</tr>
<tr>
<td>Rijnstate (III)</td>
<td>1</td>
</tr>
<tr>
<td>Spaarne (III)</td>
<td>14 (-1)**</td>
</tr>
<tr>
<td>Flevo (III)</td>
<td>1</td>
</tr>
<tr>
<td>Diaconessen (III)</td>
<td>1</td>
</tr>
<tr>
<td>Slotervaart (III)</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
</tr>
</tbody>
</table>

* later referred to this hospital
** later referred from this hospital

Twenty-three patients underwent 80 surgical procedures during their first admission (Table 2). Fourteen underwent 28 surgical procedures on the first day. Two patients were immediately transferred from the emergency department to the operating room due to life-threatening injuries. One of these patients suffered haemorrhagic shock due to pelvic fractures, intra-abdominal injuries, and severe injuries to extremities. Laparotomy was performed for haemorrhagic injuries of the liver and spleen. In addition, an external fixator was placed on the pelvis. The interventional radiologist performed embolisation of both iliac artery and splenic artery because of persistent haemodynamic instability. The second patient was also in haemorrhagic shock due to pelvic and extremity injuries. The pelvic, femur, and lower leg fractures were stabilised with external fixators, and amputation of the foot.
was performed because of uncontrollable bleeding with irreparable injury to the foot. Six patients had more than 5 surgeries during their hospital stay. All of these patients had a high ISS (between 13 and 66), and a combination of facial, extremity and spinal injuries. There was no in-hospital mortality.

Figure 3. Injuries per AIS region

'Dead and neck' includes cervical spine injuries; 'thorax' includes thoracic spine injuries; 'abdomen' includes lumbar spine injuries

Discussion

The crash received considerable attention from the national and international media, which initially reported on the quick emergency response, the extensive availability of the emergency services and the number of victims and fatalities. From that perspective, several aspects of this study are described below.

Patient Distribution

The first patient arrived at the hospital 74 minutes after the crash. Three and a half hours after the crash, 50% of the patients had not yet reached a hospital. The circumstances at the scene, including the muddy ground and several patients being trapped in the wreckage, made it difficult to evacuate all the victims quickly. As a result, the so-called ‘golden hour’ for the severely and critically injured patients had elapsed. The “golden hour” is an adage in trauma surgery, which states that all life threatening injuries must be identified and treated in a hospital within one hour of the injury, in order to minimize secondary morbidity and mortality. Even
though there is no strong scientific evidence for this, the adage is widely supported. (5) In fact, one of the deceased was still alive when the first Helicopter Emergency Medical Team (HEMS) arrived 54 minutes after the crash, but died shortly afterwards. (6) However, since no autopsy was performed on this victim, or on any of the other fatally injured passengers, it is not possible to comment on whether this outcome was influenced by the golden hour having elapsed.

Hospitals in the area were able to quickly upscale in order to create greater capacity to treat the injured. Because of unclear information about the number of casualties, several hospitals were upscaled according to the Dutch Hospital Disaster Plan (Dutch acronym: ZiROP). Upscaling should only be done in response to an official request, and means that the capacity for regular (non-urgent) care is reduced to provide greater capacity for a relatively large number of severely injured patients. In the present case, the patients were widely distributed amongst the 14 hospitals that initially were involved, some of which only received a few or just one patient. As a consequence, a number of hospitals lost regular care capacity unnecessarily. Further research is needed into the precise patient distribution during this event, as well as in regional and national patient distribution plans, to evaluate their efficiency and feasibility. Another point to be considered in future research includes the role of specialised major incident facilities, such as the Major Incident Hospital at the University Medical Centre Utrecht, the Netherlands.

Table 2. Surgical procedures carried out on 25 February 2009 on victims of the plane crash.

<table>
<thead>
<tr>
<th></th>
<th>Fractures</th>
<th>Viscera</th>
<th>Soft tissue</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Abdomen</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Spine</td>
<td>17</td>
<td>4</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Pelvis</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Upper extremity</td>
<td>9</td>
<td>3</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Lower extremity</td>
<td>24</td>
<td>11</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>58</strong></td>
<td><strong>22</strong></td>
<td><strong>80</strong></td>
<td></td>
</tr>
</tbody>
</table>

It is important to consider the decision to transfer the victims to a hospital. Considering that all of the occupants of the plane had suffered a high energy trauma, the decision to treat all victims in a hospital would appear appropriate. However, this decision was not taken until several hours after the crash, where upon all victims who had initially been attended to at casualty clearing stations were eventually transported to a hospital; only six patients remained physically unharmed by the crash and 66 people were hospitalised. This delay in transferring...
The 2009 plane crash

patients to hospital raises some concerns that will be addressed in further research into the pre-hospital triage system used.

Finally, this study has identified some issues relating to casualty triage. Pre-hospital triage records were not available in this retrospective analysis and, for most patients, the triage classification (Box 1) could not be linked to the ISS, because very few casualty triage tags were used. The evaluation report by the Dutch Public Order and Safety Directorate in cooperation with the Dutch Health Care Inspectorate mentions 35 P1 (critically injured) casualties. This number is presumably derived from estimates issued by the hospital boards at an inquiry three days after the crash. However, it is unclear whether these estimates are based on pre-hospital or in-hospital triage. The analysis of patient records carried out in this study found 15 patients to be multi-trauma patients with an ISS of ≥16. Although not each P1 victim is necessarily a multi-trauma patient, this large discrepancy between the estimated number of P1 casualties and the observed number of patients with an ISS ≥16 could indicate that there may have been some over-triage. Only three victims, all with spinal fractures, were referred to another hospital. One of these patients had an ISS of 17, and was initially taken to a Level III hospital. The other two patients, with an ISS of 8 and 9, respectively, were referred from a Level II hospital to a Level I hospital. These observations will be addressed in a more in-depth study into the triage and distribution of the victims of this plane crash.

Box 1. Triage classification according to MIMMS.

<table>
<thead>
<tr>
<th>P1 (red): Immediate/ Critical</th>
<th>P2 (yellow): Urgent/ Severe</th>
<th>P3 (green): Delayed/ Minor</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABCD unstable, in need of immediate treatment because of either: A (airway), no open airway; B (breathing), respiratory rate &lt; 10 or &gt;30; C (circulation), pulse rate &gt;120; D (disability) GCS (Glasgow Coma Score) &lt;8.</td>
<td>ABCD stable, but with possible life-threatening injuries if not treated within 6 hours.</td>
<td>ABCD stable, walking wounded.</td>
</tr>
</tbody>
</table>

Injuries

A remarkably large number of spinal and head and face injuries were found in the victims of this plane crash. Eighteen percent of all victims had one or more spinal
Chapter 2

injuries. Further analysis of the type of spinal injuries might explain the trauma mechanism: either flexion-distraction injuries due to the body flailing over the 2-point lap belt in sudden horizontal deceleration, or compression-type fractures due to the sudden vertical deceleration.

The head and facial injuries might be explained by the sudden impact, against which the passengers did not brace themselves since they had no idea they were going to crash as there had been no warning from the cockpit. Furthermore, there were few abdominal injuries. Only one patient needed a laparotomy and nine patients suffered renal contusion. These findings are in line with those from a study of a relatively similar plane crash in 1989 in the United Kingdom. (8) The nature of the trauma, being a high speed deceleration while wearing a 2-point lap belt, would be expected to cause more injuries to the vulnerable intra-abdominal viscera. Further research regarding the structural damage to the airplane, as well as the biomechanical analysis of the injuries, is outlined in chapter 10 of this thesis.

Conclusions

This study described patient distribution and injuries of victims of the February 2009 Turkish Airlines aircraft crash at Schiphol, the Netherlands, in which nine of the 135 occupants died and 120 were wounded. There was no in-hospital mortality. The analysis has shown that, even though the crash occurred in the most densely populated area of the Netherlands, with numerous hospitals nearby, a considerable period of time elapsed between the crash and the arrival of the victims at the hospitals. There were hardly any records found of the pre-hospital triage and there appears to be large discrepancies in the estimated numbers of T1 patients. Finally, evaluation of the types of injuries has revealed a remarkable number of head/facial injuries and spinal injuries. Further research is planned by the “Medical Research Turkish Airlines Crash” (MOTAC) study group into the triage, patient distribution and biomechanics of the injuries. Other relevant matters identified in the present study should provide greater insight into the events surrounding this aircraft crash.

*During the process of the several studies, certain calculations of the ISS scores needed to be revised. The injuries and AIS scores were correct but some ISS scores had been miscalculated. This has led to minor revisions of some results, which did not lead to different conclusions. In this chapter the correct results are displayed and therefore some numbers differ from the published article. These numbers are indicated with an *asterisk. The whole data set of revised results is displayed in a table in chapter 12.
References


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