Contents lists available at SciVerse ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury
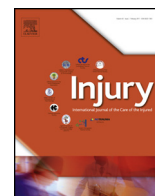
Mass casualty triage after an airplane crash near Amsterdam

CrossMark

Ingri L.E. Postma [a,1,3,*], Hanneke Weel [b,1,3], Martin J. Heetveld [c,3],
Ineke van der Zande [d,3], Taco S. Bijlsma [e,2,3], Frank W. Bloemers [b,3],
J. Carel Goslings [a,3]

[a] Academic Medical Centre, Trauma Unit Department of Surgery, Amsterdam, The Netherlands
[b] VU Medical Centre, Department of Trauma Surgery, Amsterdam, The Netherlands
[c] Kennemer Gasthuis, Department of Surgery, Haarlem, The Netherlands
[d] Safety Region Kennemerland, The Netherlands
[e] Spaarne Hospital, Department of Surgery, Hoofddorp, The Netherlands

ARTICLE INFO

ABSTRACT

Introduction: Triage is an important aspect of the management of mass casualty incidents. This study describes the triage after the Turkish Airlines Crash near Amsterdam in 2009. The results of the triage and the injuries of P3 casualties were evaluated. In addition, the role of the trauma mechanism and its effect on spinal immobilisation during transport was analysed.

Methods: Retrospective analysis of investigational reports, ambulance forms, and medical charts of survivors of the crash. Outcomes were triage classification, type of injury, AIS, ISS, emergency interventions and the spinal immobilisation during transport.

Results: A minimal documentation of prehospital triage was found, and no exact numbers could be recollected. During inhospital triage 28% was triaged as P1, 10% had an ISS $\geq$ 16 and 3% met the modified Baxt criteria for emergency intervention. 40% was triaged P3, 72% had an ISS $\leq$ 8 and 63% was discharged from the Emergency Department after evaluation. In hospital over-triage was up to 89%. Critical mortality rate was 0%. Nine per cent of P3 casualties and 17% of 'walking' casualties had serious injuries. Twenty-two per cent of all casualties was transported with spinal immobilisation. Of the casualties diagnosed with spinal injury 22% was not transported with spinal immobilisation.

Conclusion: After the Turkish Airlines Crash documentation of prehospital triage was minimal. According to the Baxt criteria the overtriage was high. Injuries sustained by plane crash survivors that seem minimally harmed must not be underestimated. Considering the high energy trauma mechanism, too little consideration was given to spinal immobilisation during transport.

© 2013 Elsevier Ltd. All rights reserved.

Introduction

In a disaster or mass casualty incident (MCI), a rapid assessment and treatment of the injured is important. On February 25, 2009 a Boeing 737-800 from Turkish Airlines crashed with 135 people aboard, nine people died at the scene. One hundred and twenty six casualties needed triage. Emergency Services in the Netherlands have experience with MCIs, e.g. 245 casualties in the Volendam café fire in 2001 and 944 casualties in the Enschede fireworks explosion in 2000.[1–3] In previous MCIs difficulties with triage occurred like pre-hospital services employing different or inadequate triage methods [2–7, pp. 50–52]. At the Volendam café fire few triage scores were documented at the scene of the accident: the prehospital triage of the burns casualties was inadequate and did not lead to treatment and transport priorities.[2,3]

The triage of trauma casualties is meant to allocate casualties to the appropriate hospital, bearing in mind reducing mortality and morbidity of individual casualties and secondly cost effectiveness.[8,9] In the everyday situation there is no need to attend to the 'greatest good to the greatest number of people.' A difference with triage during disasters and large MCIs is that medical capacity is limited, resulting in a need for lower over-triage rates in order to

P1 (red): Immediate/ Critical: ABCD unstable, in need of immediate treatment because of either: A (airway), no open airway; B (breathing), respiratory rate < 10 or >30; C (circulation), pulse rate >120; D (disability) GCS (Glasgow Coma Score) <8.

P2 (yellow): Urgent/ Severe: ABCD stable, but with possible life-threatening injuries if not treated within 6 hours.

P3 (green): Delayed/ Minor: ABCD stable, walking wounded.

Fig. 1. Triage Sieve classification according to MIMMS.

prevent an overburdened medical system.[10,11] In MCIs of bomb blasts the critical mortality rate (number of critically injured casualties that died on the way to, or in hospital) has proven to be directly related to overtriage.[10,12,13]

The Triage Sieve and Sort Algorithm is a component of the Major Incident Medical Management and Support (MIMMS) course based on physiological parameters like ability to walk, airway patency, breathing rate and pulse rate and was (and is still) the current practice in MCIs in the Netherlands during the Turkish Airlines Crash (TAC) in 2009 (Fig. 1).[14,15, p. 53]

The guidelines for field triage by the American College of Surgeons describe mechanisms of injury that might indicate a high energy impact, and casualties of such an injury mechanism should be transported to a trauma centre for Advanced Trauma Life Support (ATLS®) resuscitation and subsequent treatment of their injuries.[8,9] As an airplane crash deviates from regular trauma mechanisms, medical personnel might not be familiar with expected injuries in casualties of an airplane crash.

In this study several triage-related issues after the TAC are evaluated. The research questions were:

(1) Triage process:
 a. What were the results of the prehospital and inhospital triage process of the casualties of the TAC crash?
 b. How did triage classifications relate to clinical outcomes?
(2) P3 and walking wounded:
 a. What were the injuries of the P3 casualties and 'walking' casualties?
 b. What was the expected severity of their injuries?
(3) Mechanism of injury and spinal immobilisation:
 a. Did trauma mechanism play part in this mass casualty triage?
 b. How did this effect spinal immobilisation rate during transport?

This retrospective study has been approved by the Institutional Review Board of the Academic Medical Centre Amsterdam.

Setting

Turkish Airlines flight TK1951 crashed at 10:26 am in a field 1.5 km before the runway of Schiphol international airport, near Amsterdam (Fig. 2). Nine people did not survive the impact of the crash. Casualties were transported to a total of 14 hospitals ranging from 5.8 to 53.5 km from the crash site. The majority (86%) was transported to a hospital within a 25 km distance.[16]

Methods

A retrospective analysis was performed of available ambulance forms, the registered information of the 3 deployed Helicopter Emergency Medical Service (HEMS) teams and the present triage cards of the casualties. We also used the collected data of the events as described in investigational reports of the Dutch Health Inspectorate and Dutch Safety Board.[17–19]

The prehospital data collected were: gender, age, vital signs and revised trauma score (RTS), triage classification, use of triage cards, time of transport and arrival at Emergency Department and medical interventions.

Inhospital data included: trauma level of the receiving hospital, inhospital triage classification, documented injuries, Abbreviated Injury Scale (AIS), Injury Severity Score (ISS) and medical procedures. The inhospital triage classification reported in the investigational reports of the Dutch Health Inspectorate and Dutch Safety Board was utilised for our study purposes. These data were not documented per individual casualty but only as a group and therefore no comparison with individual diagnosis or ISS was possible. The data consisted of estimations reported during evaluation interviews by the hospitals involved and crosschecked with the collection of individual injuries and ISS scores in our own database.

An indicator of the performance of triage is the critical mortality rate, representing the number of critical casualties (P1) that died on the way to or in the hospital.[4,10,12,20]

Triage classification

We compared the triage classifications with 2 clinical outcomes; Injury Severity Score (ISS) and the modified Baxt criteria.[21–23] For the comparison with ISS we analysed how the P1 category correlated with an ISS ≥ 16, P2 with an ISS 9–15, and P3 with an ISS ≤ 8. Second, we used the modified Baxt criteria (from now on

Fig. 2. The scene of the accident.

Modified Baxt Criteria

- Chest decompression (needle or tube thoracostomy)
- Intravenous fluids for a systolic blood pressure < 90 mm Hg, or absence of radial pulse.
- Blood transfusion.
- Assisted ventilation or open airway procedure.
- Invasive central nervous system monitoring with brain imaging or other evidence of increased intracranial pressure.
- Non-orthopaedic operation (or pelvis stabilization) with positive findings within 6 hours.

P1:   ISS ≥16:   One of modified Baxt criteria within 6 hours of crash: +
P2:   ISS 9-15:   No Baxt criteria but admission > 24 hours.
P3:   ISS ≤8:   No Baxt criteria and discharged < 24 hours.

Fig. 3. Modified Baxt criteria.

called 'Baxt criteria') and hospital admission shown in Fig. 3. The Baxt criteria consist of emergency interventions patients have undergone in order to treat acute life threatening injuries. Patients who met the Baxt criteria are considered P1. Patients who did not meet Baxt criteria but were admitted to hospital for at least 24 h were considered P2. Patients that did not meet Baxt criteria and were discharged within 24 h are considered P3.[21–23]

We evaluated the processes of triage and different outcomes from prehospital and inhospital triage. Overtriage was calculated by dividing the number of noncritical casualties triaged as P1, by the total number of P1 triaged casualties.[12,20,22] Undertriage was calculated as the ratio of critically injured casualties, and casualties with an ISS ≥ 16 that were not transported to a level one trauma centre.[9,24]

Pre-hospital P3 and 'walking' casualties

Casualties triaged as P3 (delayed) were determined by either a documented P3 triage classification on the ambulance form or on the triage tag. Another subgroup of P3 casualties was determined by documentation of their presence in the last casualty clearing station. In this casualty clearing station casualties triaged P3 were initially gathered in order to be reunited with their families. Later it was decided that these casualties also needed inhospital evaluation because of the high energy trauma mechanism.[17,19] Duplicates within both groups were filtered out and the subgroups were analysed together as one. Of this group we analysed the injuries and treatment.

In the Triage Sieve algorithm the first determination is done by noting whether the casualty is walking.[15] When walking, casualties are triaged as either P3 (if injured) or uninjured. We identified casualties that were reported (by documentation on ambulance form) to have come 'walking' from the aircraft wreckage or crash site. We also made calculations for these groups (P3 and walking wounded) combined (taken out duplicates) in order to study the underestimation of the injuries of this category. To be able to see if the frequently used triage term 'walking wounded' is accurate in excluding major injuries we analysed their injuries and treatments (operative or non-operative).

In order to report the extent of the injuries and possible need for hospital evaluation, we determined the highest AIS score of each of the P3 casualties and each of the walking wounded.

Trauma mechanism and spinal immobilisation

During the triage process all casualties were eventually considered to have been subjected to a high energy trauma mechanism. We gathered documentation of spinal immobilisation during transport on the ambulance forms and diagnosis of spinal injury and the inhospital treatment.

The data were collected, stored and analysed using SPSS® 16.0 (SPSS® for Windows® version 16.0, IBM® corporation, U.S.A.).

Results

Events

A house and 2 barns next to the crash site functioned as improvised casualty clearing stations (CCS). It was reported that in the house about 20 of the most severely injured casualties were gathered (in the investigational reports called P1), and in the 2 barns about 70–75 of the less severely and minimally injured (in the investigational reports referred to as P2 and P3).[17,19] Some casualties were trapped in de wreckage. At least 37 minimally injured casualties (in the investigational reports referred to as P3) were later transported to a third CCS in a sports centre, which was the pre-assigned CCS in the MCI protocols. This CCS is supposed to be mainly for P3 casualties. Here during retriage, 2 casualties were found to be severely injured (P1) and 17 to have major injuries (P2). Then it was decided by that all casualties suffered a high energy trauma and therefore all casualties should be evaluated in hospital according to ATLS® principles.

Two casualties left the crash site by themselves and were not triaged but reported to a hospital later that day and the day after the crash. They are not accounted for in the results. The other 124 occupants were transported to 14 different hospitals within a median time of 3.5 h after the crash. We retrieved ambulance forms of 91 patients, which contained heterogeneous and incomplete data.

In this article the crash site, the house and two barns, which were the first improvised CCS, together are referred to as 'the scene of the accident.' The third CCS, being the pre-assigned sports centre, is referred to as the CCS. The means of transport are summarised in Fig. 4.

Triage classification

We found documentation of a prehospital triage classification on 27 of the 91 ambulance forms (30%, 2 P2 and 25 P3). Few triage tags were used and only 11 were retrieved.[17,19]

The result of the triage classification, ISS and Baxt criteria are shown in Table 1. It was reported from the scene that there were 20 P1 casualties.[17,19] When considering an ISS ≥ 16 as a measure of P1 casualties, 7 (35%) of those 20 casualties should not have been triaged P1. Using the Baxt criteria the prehospital overtriage was 80%.
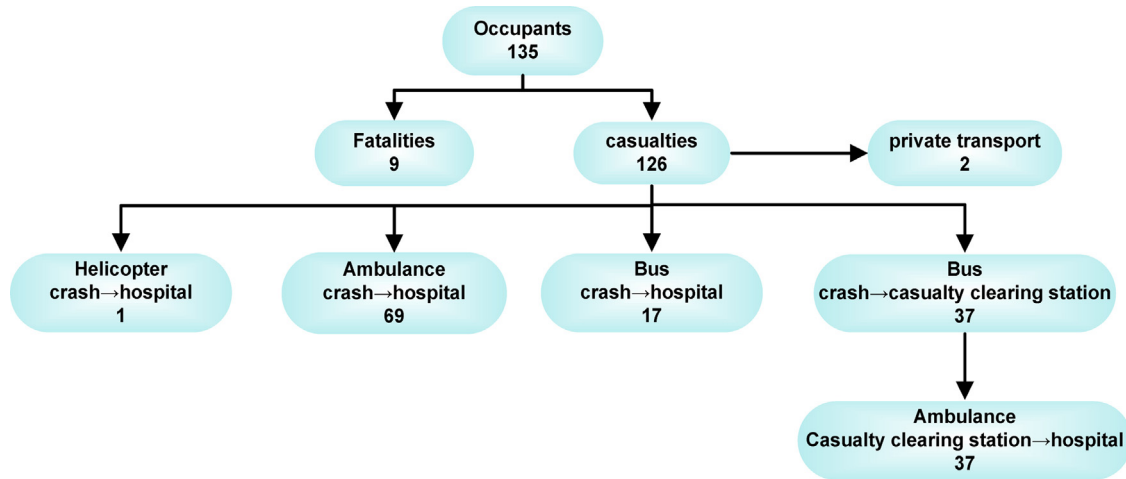
Fig. 4. Transportation.

The inhospital overtriage would be 63% if calculated with ISS and 89% with the Baxt criteria. All casualties were evaluated in a hospital, and all casualties who needed emergency intervention (Baxt criteria) were transported to a level 1 trauma centre. Eighty-nine per cent of the casualties with inhospital P1 triage and 92% of casualties with ISS ≥16 were transported to a level 1 trauma centre, giving an undertriage rate of 11% and 8% respectively.

No casualties died on the way to or in hospital; therefore the critical mortality rate was 0%.

P3 and walking wounded

We identified 34 casualties as P3 either by documentation on their ambulance form or because they went through the CCS. Among those are several victims that were later re-triaged as P2 or P1, because of existing injury, not because of clinical deterioration (information by word of mouth). We could not identify those casualties that were upgraded in triage classification. One P3 patient was later diagnosed with a bilateral lung contusion, a spinal fracture, and an ankle fracture, resulting in an ISS of 22.

On the ambulance forms of 23 casualties it was reported that they came walking from the wreckage by themselves. One 'walking' casualty was diagnosed with a tibia fracture, 2 spinal fractures, and a kidney contusion (ISS 17).

Combing these two groups and extracting duplicates we identified 50 casualties within this category. The results of clinical outcomes in this category are in Table 2. The injuries diagnosed in this group with an AIS ≥ 3 were a fracture of the odontoid of the 2nd cervical vertebra, 5 thoracolumbar spine fractures (in 3 casualties), a fracture of the sternum, 2 tibia fractures (bilateral in 1 patient), 2 cerebral contusions and one retina lacerations.

Spinal immobilisation

Documentation on transport with or without spinal immobilisation was found for 83 casualties. It can be assumed (and was

reported verbally to the authors) that the 17 patients transported together in a bus had no spinal immobilisation. Of the 126 survivors, 23 had a spinal injury, 4 of whom we determined received no immobilisation on transport. Ten patients needed surgical treatment for their spinal injury of whom 1 was not immobilised during initial transport. The data on spinal immobilisation during transport are shown in Table 3.

Two (6%) of the P3 casualties were later diagnosed with spinal injury, but were not immobilised during transport. Separate from these 2 there were also 2 (9%) of the 'walking' casualties with a spinal fracture that were not immobilised. One of them needed operative treatment for the spinal injury.

Discussion

Before the discussion of the individual topics is started it must be noted that this paper is in no way intended to criticise the individual work of the emergency responders who all contributed to saving

Table 1
Triage disposition according to location and injury criteria.

	P1	P2	P3	Total
Prehospital triage[a]	Unknown	≥2	≥34	124
Inhospital triage	35 (28%)	40 (32%)	49 (40%)	124
ISS	13 (10%)	22 (18%)	89 (72%)	124
Baxt (see also Fig. 3)	4 (3%)	42 (34%)	78 (63%)	124

[a] From the prehospital triage documentation of only 36 victims (2 P2, 34 P3) was found.

Table 2
Results of P3 and 'walking' casualties.

	P3 and walking (*n* = 50)
Mean ISS (median; IQR; range)	4.1 (2; IQR 1/5; 0–22)
Hospitalised	17 (34%)
Mean no. of days in hospital (median; IQR; range)	7 days (3; 2/10; 1–17)
Fracture	11 (22%)
Spinal fracture	7 (14%)
Surgery	7 (14%)
Surgery for spinal fracture	5
At least 1 moderate injury (AIS ≥ 2)	22 (44%)
At least 1 serious injury (AIS ≥ 3)	6 (12%)

Table 3
Transportation to 1st receiving hospital.

	Spinal injury	No spinal injury	Total
Full immobilisation	11 (61%)	7 (9%)	18 (17%)
Only spine board	3 (17%) (no C-spine collar)	3 (4%)	6 (6%)
Only collar	0	1 (1%)	1 (1%)
No immobilisation	4 (22%)	54 (83%)	58 + 17[a] (75%)
Total	18[b]	65	100[a]

N = 100; no of casualties with documentation about spinal immobilisation.
[a] We assume that the 17 patients transferred together in a casualty bus were without spinal immobilisation.
[b] Excluding 5 patients with unknown immobilisation.

lives and minimising harmful results of the crash. This evaluation is performed mostly by hospital professionals and might therefore insufficiently capture the complexity of prehospital workflow.

Triage

The evaluation of the triage process after the TAC was difficult because there was a small amount of individualised data on prehospital and inhospital triage. It is remarkable how little triage tags were used, namely in 12% of casualties of whom we found prehospital data. Evaluations of other MCIs around the world have shown the same.[25,26] The National Protocol Ambulance Care does prescribe the use of casualty/triage tags[15, p. 20]. There has been criticism on the layout of triage tags themselves and also on the fact that ambulance personnel are unfamiliar with the use in daily practice. In the management of an MCI, deviation from daily routine has shown to be difficult.[19,25] This has been mentioned as an explanation why the tags were not used in the TAC. In the TAC 'only' 126 casualties needed evaluation. In larger incidents, with greater amounts of casualties (e.g. Madrid bombing 2004 with more than 2000 casualties) practical sorting methods of triaged casualties are indispensable. Some plead for geographical triage instead of using triage tags, because in MCIs with >20–25 casualties triage tags could be impractical.[26] In a way this was done at the TAC for most of the P3 casualties who were transferred to a separate CCS. The use of triage tags and feasibility of implementation in daily practice should be investigated. This asks for a casualty/triage tag with enough space for identification information, medical information and triage category which can be altered during the process. The goal should be to create a tag/card (maybe digital) that has use during day to day casualty management and is also applicable in MCIs.

In the research of the TAC we focused on the possible overtriage of P1 casualties and the possible underestimation of the injuries of P3 casualties. In an MCI where there is no shortage of medical care, non-life threatening injuries have a greater importance than in disasters, especially in developed countries with high standards of medical care.

Overtriage was not defined by the level of trauma centre where casualties were transported to, because ambulance personnel could have chosen to transport casualties with minor or moderate injuries to a level 1 trauma centre because of their large capacity rather than because of the specialised care.[9,27] Because all casualties were eventually evaluated in a hospital no undertriage was present in that way. Therefore we evaluated undertriage to standards of daily practice, not MCIs, which determines whether critically injured casualties are transported to the highest level of care in the region.[9] Overtriage rates are high (80–89%) when considering the Baxt criteria, but when using the ISS as a measure the rates were lower (35–63%). However, an ISS ≥ 16 can consist of all none (acutely) life-threatening injuries and ISS should not be used as a sole mean to define critically injured casualties as in the P1 triage classification.[21,22]

In daily practice a certain amount of overtriage is accepted to diminish under triage. It has been stated that in MCIs and disasters an overtriage rate of 50% must be accepted to diminish undertriage to zero.[12] However, the American College Surgeons states that in daily practice an undertriage of 5% is acceptable with an associated overtriage rate of 25–50%.[9,28] The overtriage rate of P1 casualties in TAC of up to 89% is high, as was the undertriage rate of P1 casualties of up to 12%. This was not reflected in the critical mortality rate (0%), which could be due to the large availability of medical resources in this setting.[29] In descriptions of other MCI the undertriage rates are mostly not evaluated. Our 12% undertriage is calculated from a daily practice standard, and can be considered low for a MCI.

The high inhospital overtriage rates could be due to inaccurate use of the P1 triage classification. In an evaluation report a major trauma centre mentions to, at a certain time have received '5 P1 casualties of whom 2 had acute life threatening injuries.'[30] According to the MIMMS Triage Sieve, the 3 casualties without acute life threatening injuries should not have been triaged P1.

P3 and 'walking' casualties

In the TAC medical management it appears to have been unclear how to manage casualties triaged as P3, as 37 P3 casualties were almost sent home, but were later assigned entitlement to inhospital evaluation. In the patient distribution plan of the region it is stated that 'inhospital treatment only applies to major injuries (P1 and P2).' 'Casualties with less serious injuries (P3) are only taken in account as a hindrance at the scene of the accident and at the hospital entrance.'[31,32] The investigational report of the Dutch Health Care Inspectorate mentions that 'P3 casualties can be treated at the scene by medical assistance teams.'[17] In our opinion, this is an incorrect interpretation of the MIMMS triage method, which determines that P3 casualties have no *transport* priority and need not necessarily be transported by ambulance initially. MIMMS does not advocate that inhospital evaluation of P3 casualties should be withheld.[14]

Our data show that casualties from an airplane crash who are walking and/or triaged as P3 can still have major injuries, including spinal fractures. Some casualties might not immediately experience the physical pain caused by these injuries because of high levels of stress hormones released directly after the survival of such an accident. Repeated evaluation of casualties (retriage), as was done in the CCS, is therefore necessary.

If all P3 and walking wounded in the TAC had not been evaluated in hospital an increase in morbidity and possibly mortality could have resulted. Use of contradictory terms and protocols must be avoided in managing MCIs. It must also be clear to everyone in the field what the definition is of terms used in these protocols. For example 'walking wounded' should not be explained as 'not injured' or 'not entitled to hospital evaluation.'

Trauma mechanism and spinal immobilisation

According to the field triage rules by the American College of Surgeons all casualties of a high energy impact should be considered for evaluation in a major trauma centre rather than a level II or III trauma centre, based on the expected severity of the injuries.[9] In everyday practice in the Netherlands, if expected injuries are less severe, high energy trauma casualties can also be transported to level II hospitals.[15] The criteria of high energy impact are defined for more common trauma mechanisms like falls from height or motor vehicle accidents, but not for rare accidents like plane crashes.[9] The one criterion most applicable for this plane crash was 'death in the same passenger compartment,' being 6 people who were seated in the passenger compartment that did not survive the impact of the crash. The decision that all casualties should be evaluated in hospital on the basis of the high energy trauma criteria was therefore justifiable.

In the TAC 75% of the casualties had no spinal immobilisation during transport to hospital, and 22% of the casualties eventually diagnosed with spinal injury were not transported with immobilisation. The MIMMS states that 'full spinal immobilisation is impractical for all casualties of, for example, a rail crash, even though they are exposed to the same mechanism of injury. Clinical judgement must be exercised to a greater extent than in a single casualty blunt trauma incident.'[14] The trauma mechanism of this plane crash has put several parts of the spinal column at risk for injury. Ninety-two of the 126 survivors had a head or facial injury

probably due to a blow to the head by flying loose objects or by hitting the head itself against the planes' interior, putting the cervical spine at risk.[33] The crash could have been assumed to have been accompanied with horizontal and vertical deceleration forces.[18] This might have resulted in a blow to the thorax by hitting the seat in front compressing the thorax and or flailing over the seatbelt compromising the lumbar spine in the horizontal deceleration force. Considering a possible vertical deceleration, a direct compression force is applied to the entire spine especially in seating position. For decision making about cervical spine immobilisation the NEXUS criteria are the basis of the Dutch ambulance protocol.[15] In this type of trauma the NEXUS criteria seem to be incomplete. In the TAC availability of medical resources like ambulances and immobilisation material was not sparse, so more casualties could have been transported with spinal immobilisation. In retrospective the Dutch ambulance protocol appeared also to be insufficient to clear the spine as a whole. The mechanism of injury must be accompanied by symptoms like pain in spine, not alert patient (GCS < 15 or intoxication), distracting injury, neurological deficit, facial (not head) injury or suspicion of basilar skull fracture, in order for the ambulance personnel to immobilise the spine.[15] If the trauma mechanism would have been considered at an earlier stage, emergency medical personnel at the scene probably would have immobilised more casualties.

In summary the TAC was not a disaster, since there was enough medical capacity to manage all casualties with high standards of care. This is reflected in the critical mortality rate of 0%. But when a crash like this happens the magnitude cannot fully be predicted in the first moments of pre-hospital care. Therefore it is the right thing to start triaging as if it is a disaster where it is expected that there will be a lack of capacity. This means first (all) P1 casualties should be identified by physiological parameters as with the Triage Sieve. The rest, being P2 and P3 casualties can wait. Later when the scale of the incident is clear and it can be assumed that there is enough capacity that high standards of care can be delivered to every casualty, the incident should be downgraded to a MCI where normal triage and standards of care can be applied. This takes into account not only physiological parameters and injury type, but also mechanism of injury. In retrospective this was in general the actual course of the management of the TAC.

Conclusion

After the Turkish Airlines Crash documentation of triage was minimal. According to the Baxt criteria there was a high percentage of overtriage (up to 89%), which can be desired in daily practice to minimise undertriage, but is less desirable in MCIs and disasters. Over- and undertriage did not result in an increase of mortality, since the critical mortality rate was 0%. The possible injuries sustained by the P3 casualties should not be underestimated, as major injuries were diagnosed in this group. In an airplane accident, such as described in this study, spinal immobilisation should be considered for transport of all survivors.

Funding

Conflict of interest

There has been no conflict of interest for this article.

Acknowledgements

References

1. Vugt van AB. Disaster medicine: lessons from Enschede and Volendam. *Ned Tijdschr Geneeskd* 2001;**145**:2309–12.
2. Juffermans J, Bierens JJ. Recurrent medical response problems during five recent disasters in the Netherlands. *Prehospital Disaster Med* 2010;**25**:127–36.
3. Welling L, van Harten SM, Henny CP, Henny CP, Ubbink DT, Kreis RW, et al. Reliability of the primary triage process after the Volendam fire disaster. *J Emerg Med* 2008;**35**:181–7.
4. Aylwin CJ, König TC, Brennan NW, Shirley PJ, Davies G, Walsh MS, et al. Reduction in critical mortality in urban mass casualty incidents: analysis of triage, surge, and resource use after the London bombings on July 7, 2005. *Lancet* 2006;**368**:2219–25.
5. Carresi AL. The 2004 Madrid train bombings: an analysis of pre-hospital management. *Disasters* 2008;**32**:41–65.
6. Staff of the accident and emergency departments of Derbyshire Royal Infirmary, Leicester Royal Infirmary, and Queen's Medical Centre, Nottingham. Coping with the early stages of the MI disaster: at the scene and on arrival at the hospital. *BMJ* 1989;**298**:651–4.
7. Wallace WA, Rowles JM, Colton CL. *Management of disasters and their aftermath*. London: BMJ Publishing Group; 1994.
8. Barraco RD, Chiu WC, Bard MR, Bokhari F, Borzotta A, Blow O, et al. *Practice management guidelines for the appropriate triage of the victim of trauma*. Eastern Association for the surgery of Trauma. http://www.east.org/tpg/TraumaTriage.pdf; 2010.
9. National expert panel on field triage. *Guidelines for field triage of injured patients. Recommendations of the National Expert Panel on field triage.* Centre of Disease Control in collaboration with American College of Surgeons Committee on Trauma. http://www.cdc.gov/mmwr/preview/mmwrhtml/rr6101a1.htm; 2009 and 2011.
10. Frykberg ER. Triage principles and practice. *Scand J Surg* 2005;**94**:272–8.
11. Iserson KV, Moskop JC. Triage in medicine, part I: concept, history, and types. *Ann Emerg Med* 2007;**49**:275–81.
12. Frykberg ER. Medical management of disasters and mass casualties from terrorist bombings: how can we cope? *J Trauma* 2002;**53**:201–12.
13. Hirshberg A, Scott BG, Granchi T, Wall Jr MJ, Mattox KL, Stein M. How does casualty load affect trauma care in urban bombing incidents? A quantative analysis. *J Trauma* 2005;**58**:686–95.
14. Hodgetts TJ, Porter C. *Major incident medical management and support*. London: BMJ Books; 2002.
15. NVMMA, V&VN AZ. *National Protocol Ambulance Care (NPA; Landelijk Protocol Ambulance Zorg LPA) 7.2*. Zwolle. http://www.ambulancezorg.nl/engels [accessed 2011].
16. Postma ILE, Weel H, Heetveld MJ, Zande van der I, Bijlsma TS, Bloemers FW, Goslings JC. Patient distribution in a mass casualty event of an airplane crash. *Injury* 2013. in press.
17. Dutch Ministery of Interior and Kingdom Relations, Public Order and Safety Directorate, Health Care Inspectorate. *PolderCrash 25th February 2009. Investi-*

gation report from government of the Netherlands' website. http://www.rijkso-verheid.nl/documenten-en-publicaties/rapporten/2009/06/22/eindrapportage-poldercrash.html [accessed 22.06.09].

18. Dutch Safety Board (Onderzoeksraad voor de Veiligheid). *Crashed during approach, Boeing 737-800, Amsterdam Schiphol Airport. Official investigation report from Dutch Safety Board website.* http://www.onderzoeksraad.nl/en/index.php/onderzoeken/Neergestort-tijdens-nadering/ [accessed 6.05.10].

19. Dutch Safety Board (Onderzoeksraad voor de Veiligheid). *Emergency assistance after Turkish Airlines aircraft accident, Haarlemmermeer. Official investiagtion report from Dutch Safety Board website.* http://www.onderzoeksraad.nl/en/index.php/onderzoeken/turkish-airlines-crisis-en-hulpverlening/ [accessed 6.06.10].

20. Frykberg ER, Tepas III JJ. Terrorist bombings, lessons learned from Belfast to Beirut. *Ann Surg* 1988;**208**:569–76.

21. Baxt WG, Upenieks V. The lack of full correlation between the Injury Severity Score and the resource needs of injured patients. *Ann Emerg Med* 1990;**19**:1396–400.

22. Kahn CA, Schultz CH, Miller KT, Anderson CL. Does START triage work? An outcomes assessment after a disaster. *Ann Emerg Med* 2009;**54**:424–30.

23. Garner A, Lee A, Harrison K, Schultz CH. Comparative analysis of multiple-casualty incident triage algorithms. *Ann Emerg Med* 2001;**38**:541–8.

24. Norcross ED, Ford DW, Cooper ME, Zone-Smith L, Byrne TK, Yarbrough 3rd DR. Application of American College of Surgeons' field triage guidelines by pre-hospital personnel. *J Am Coll Surg* 1995;**181**:539–44.

25. Vayer JS, Ten Eyck RP, Cowan ML. New concepts in triage. *Ann Emerg Med* 1986;**15**:927–30.

26. Garner A. Documentation and tagging of casualties in multiple casualty incidents. *Emerg Med* 2003;**15**:475–9.

27. Rehn M, Eken T, Krüger AJ, Steen PA, Skaga NO, Lossius HM. Precision of field triage in patients brought to a trauma centre after introducing trauma team activation guidelines. *Scand J Trauma Resusc Emerg Med* 2009;**17**:1.

28. American College of Surgeons. *ACS-COT: resources for optimal care of the injured patient: 2006.* http://www.facs.org/trauma/verificationhosp.html [accessed 2006].

29. Rijksinstituut voor Volksgezondheid en Milieu. *Time to travel to nearest hospital. Nationale Atlas Volksgezondheid.* http://www.zorgatlas.nl/zorg/ziekenhuiszorg/algemene-en-academische-ziekenhuizen/aanbod/reistijd-tot-dichtstbijzijnde-ziekenhuis/#breadcrumb; 2009.

30. Coordinator, Hospital Disaster plan. *Evaluation report of hospital disaster plan after Turkish Airlines Crash AMC.* Amsterdam; 2009.

31. Safety Region Kennemerland. *Medical assistance in casualties and disasters (GHOR). Patient distribution plan (Gewondenspreidingsplan).* Haarlem; 2007 (updated 2008).

32. Safety Region Kennemerland (Veiligheidsregio Kennemerland). *Crisis plan Kennemerland.* Haarlem. www.haarlemmermeer.nl/bis/dsresource?objectid=17790&type; 2007.

33. Postma IL, Winkelhagen J, Bloemers FW, Heetveld MJ, Bijlsma TS, Goslings JC. February 2009 airplane crash at Amsterdam Schiphol airport: an overview of injuries and patient distribution. *Prehospital Disaster Med* 2011;**26**:299–304.