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Experience in managing an urban massive burn incident: The Hangzhou bus attack on 5 July 2014

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Abstract

Background: On 5 July 2014, a suicide terrorist set a crowded bus on fire in Hangzhou, injuring 33 passengers. Among these, 19 adult victims with the most severe burns were triaged to our center. This is a single-center, descriptive study recording the prehospital response and in-hospital treatment of these patients.

Methods: Information on the attack, on-scene rescue, and patient triage was collected from public media, governmental, and hospital reports. Information on patient injury and our in-hospital procedures was collected from the emergency registry and patient records.

Results: Of the 80 passengers in the burning bus, 33 were injured. The total burn surface area (TBSA) of the 19 most severely injured patients triaged to our hospital ranged from 25% to 95% (mean 48.3 ± 2.08%). Two patients had a TBSA of >90% (92% and 95%) and eight had a TBSA of >60%. Nineteen cases of inhalation injury were diagnosed, eight of which were severe. The emergency center performed 14 bedside escharotomies, 14 central venous catheter (CVC) implantations, and one cardiopulmonary resuscitation (CPR). Approximately 131 000 ml of resuscitation fluid was infused within the first 24 h and 111 000 ml within the second; further, 160 230 ml of plasma and 4100 ml of red blood cells were infused during the antishock stage.

All victims were transported to the burn ward to receive burn-centered multidisciplinary care. The respiratory team conducted 121 bronchoscopies. A total of 89 operations were performed, and the residual wound area decreased dramatically. After 124 days of extensive therapy, complete wound healing was observed and all patients entered the rehabilitation stage.

Conclusion: Adequate preparation, including planning and disaster drills, is crucial for handling mass casualty events. Efficient and precise first rescue and triage can reduce prehospital mortality, and burn-centered multidisciplinary care and hospital–government cooperation helps reduce in-hospital mortality. Nevertheless, lessons can be drawn from this incident to be better prepared for future disasters.

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1. Introduction

In China, on 5 June 2009, 27 people were killed and 74 injured when a suicide terrorist set fire to a bus in urban Chengdu. Four years later, a similar attack occurred in another bus in Xiamen, killing 47 and injuring 34. In 2014, the Guiyang bus bombing attack on February 27 resulted in six deaths and 35 injuries. On 1 March, five Islamic fundamentalists took part in the knife massacre at the Kunming Railway Station, killing 29 people and injuring another 143. On 2 August, 68 people died and >150 sustained severe burns in an accidental factory explosion in Kunshan.

Terrorist attacks have resulted in thousands of casualties worldwide, from the 9/11 World Trade Center attack in New York to the Madrid train explosion and London subway bombing [1–3]. With the increasing incidence of such manmade disasters, millions of people now face such threats in their daily lives.

A mass casualty event is defined as a situation wherein the number of patients and the severity of their injuries exceed the capability of the existing facilities to deliver care in a routine fashion [4]. In the prehospital emergency stage, rapid evacuation and triaging to receiving institutions requires the mobilization of all available social, government, media, medical, and even military resources [5,6]. A well-organized multidisciplinary approach is crucial for treatment during the in-hospital stage [7].

On 5 July 2014, during afternoon rush hour, a suicide terrorist set a crowded bus on fire in the hub of Hangzhou, injuring 33 passengers; the 19 most severely injured adults were directly or secondarily triaged to our center. After 124 days of extensive therapy, complete wound healing was observed and all patients entered the rehabilitation stage. We share our experience of this event as an example of effective preparation and the insight gained from handling a mass casualty event.

2. Material and methods

This is a single-center, descriptive study recording the prehospital response and in-hospital treatment of these patients.

2.1. Prehospital resources

The Hangzhou disaster emergency plan was first established after the severe acute respiratory syndrome (SARS) crisis of 2003. With the aim of preventing another worldwide epidemic, the original plan mainly focused on dealing with massive epidemics, including screening and identifying suspected infected patients in public crowds, isolation, and disinfections. After the Wenchuan earthquake, this plan was updated with lessons learned from massive casualties, including search, rescue, evacuation, and rapid triage. On activating these plans, a scene command center (for first aid) as well as a hospital–government coordination and communication mechanism (for long-term treatment) will be set up by the Hangzhou health bureau. These plans allow the scene commander to dispatch all essential government and public resources including fire engines, ambulances, a blood center, police, and public transportation (Fig. 1). In addition, self-organized citizens who are well trained in various exercises can ensure primary rescue and evacuation of disaster victims. However, there was no specific and detailed plan for massive burn casualty events, especially on the scene assessment and triage.

In the present case, the scene commander was the on-duty deputy director of the Health Bureau. His colleagues included the Police Commander and Ambulance Commander; the author Han Chunmiao, the local burn authority, advised the commander by telephone. He remained at Second Affiliated Hospital of Zhejiang University (SAHZU) to arrange the treatment of patients who arrived at our hospital.

![Fig. 1 – Hangzhou public health event and disaster emergency plan.](image-url)
The first wave of triage was performed by self-organized civilians. After the scene command center setup and ambulance arrival, following search, assessment and triage were performed by the scene commander and emergency doctor.

2.2. In-hospital resources

The SAHZU is a general hospital with 3200 beds in its two locations. Last year, we treated 2953 913 outpatients and 88 603 inpatients, making SAHZU one of the largest general hospitals in East China. Its four-storey emergency center (ER) has a 12-bed ward for overnight observation and a 19-bed resuscitation room; last year, this center treated 113 706 emergency patients, of whom 16 298 were trauma patients. The intensive care unit (ICU) center has four specialized units: neural ICU, surgical ICU, central ICU, and a 12-bed emergency ICU (EICU). The burn department consists of a 38-bed general ward and a nine-bed burn intensive care room. Last year, it treated >29 929 outpatients and 707 inpatients with burns or other skin/soft tissue defects, 47 with large-area burns (i.e., total body surface area (TBSA) > 30%), and 23 with extensive burns (TBSA > 50%). This unit is the burn-training center for almost all of the burn surgeons and nurses in the Zhejiang province.

In 2012, SAHZU was accredited by the Joint Commission International (JCI). This campaign helped us improve our Hospital Emergency Incident Command System (HEICS). This system ensures that the on-duty hospital president or vice president remains in the hospital to make decisions, coordinate activities, and organize the backup forces during a hospital emergency incident. A multidisciplinary life support team should be on 24-h standby, and the response time should be within 5 min of the in-hospital broadcast call.

3. Results

The No. 7 bus line connects the famous Lingyin Temple to the Hangzhou Railway Station, passing such prime tourist destinations as West Lake and half of the central business area (Fig. 2a). At 17:03 h on 3 July 2014, during Saturday afternoon rush hour, a crowded bus with >80 passengers, comprising foreign tourists and commuters returning home, was set aflame. According to the in-bus monitor, the terrorist set the bus on fire by dumping a bottle of lacquer thinner on the floor and igniting it with a cigarette lighter. The back half of the bus was completely engulfed in flames and smoke within only 4 s (Fig. 2b and c). Dozens of civilians, building safety guards, and private car/taxi/bus drivers at the scene broke the windows to help evacuate the trapped passengers and doused the fire using fire extinguishers and fire hoses (Fig. 2d). Within 5 min, the fire was extinguished when the fire engine arrived, and the first evacuated victims were transported to the nearest hospitals by private cars and taxis. The Hangzhou public health event and disaster emergency plans were activated. The Hangzhou health bureau set up a scene command center, and 21 ambulances were mobilized to first assess and triage the patients. Within 40 min, all 33 patients were triaged to the five nearest hospitals. However, before the scene command center setup and ambulance arrival, the first 10 evacuated patients were transported by civilian cars to the two nearest hospitals, which did not have a burn ward. The command center then conducted the secondary triage (Fig. 3b). At the same time, the blood center was mobilized to supply >50 000 ml of plasma within the first 24 h.

3.1. In-hospital stage

3.1.1. Emergency and antishock stage

The first victim arrived at our ER 17 min after the fire began, which alerted the hospital to prepare for the burn patients to follow. The on-duty burn surgeon then decided to activate the HEICS. Within 5 min, the resuscitation room and observation room were cleared by triaging the existing patients to corresponding units elsewhere or to another hospital, and a life support team including an ear, nose, and throat surgeon, anesthesiologist, and nurse was readied (Fig. 3a). All 17 burn surgeons were called in. Fifteen adult patients were primarily triaged to our hospital. At the same time, the deputy director of our burn center was dispatched to consult the 18 victims in the other two area hospitals. Based on his suggestions, the four most severely injured adult patients were secondarily triaged to our center, three pediatric patients were triaged to the burn ward of the Children’s Hospital Affiliated to Medical College of Zhejiang University (CHAZU), and the other 11 patients with mild burns were treated in the burn wards of the other two hospitals or discharged for outpatient monitoring (Fig. 3b). The basic patient information on these 19 severely injured adults is listed in Table 1. The total burn surface area (TBSA) ranged from 25% to 95% (mean 4.3 ± 2.08%). Two patients had a TBSA of >90% (92% and 95%) and eight patients had a TBSA of >60%. Nineteen inhalation injuries were diagnosed using bronchoscopy: three cases were mild, eight were moderate, and eight were severe. In the emergency center, 14 bedside escharotomies, 14 central vein catheter implantations, and one cardiopulmonary resuscitation were performed (Fig. 3c and d). After emergency treatment, patients were triaged to the central ICU, emergency ICU, and burn ICU for further debridevement, dressing, and fluid resuscitation. Within the first 24 h, 131 000 ml of resuscitation fluid was infused and 111 000 ml in the second 24 h. A total of 160 230 ml of plasma and 4100 ml of red blood cells were infused during the antishock stage. One patient with postburn acute renal failure received continuous renal replacement therapy.

3.1.2. Burn-centered multidisciplinary therapy stage

After patients had safely passed the 48-h resuscitation stage, government representatives, hospital leadership, and the directors of relevant clinic/medical technology departments held a joint consulting conference making the following decisions:

(1) For better infection control and wound-centered therapy, the previous patients were transferred to other departments or to another hospital for follow-up treatment. After the burn center was emptied and sterilized, all bus attack patients were shifted to the burn ward. The SAHZU burn center did not admit any new burn patients until the earlier bus attack patients were stabilized or discharged; the other two area hospitals would handle this function (Fig. 4a).
Fig. 2 – Fire and on-scene rescue. (a) The No. 7 bus line (blue lines; white dots indicate bus stops), with the red arrow indicating the fire location; blue arrow indicates the location of SAHZU. (b) Terrorist sets the fire with lacquer thinner. (c) Victims are engulfed by fire and smoke within only 4 s. (d) Civilians broke the windows and helped evacuate the trapped victims. (For interpretation of the references to color in figure legend, the reader is referred to the web version of the article.)
(2) As the care, wound dressing, and surgery of patients with severe burns is both time consuming and labor intensive, doctors and nurses trained in our burn center (including those from other hospitals) were called in for reinforcement in shifts.

(3) Multidisciplinary care was provided for critically injured patients. Several specialized teams were intimately involved: life/vital organ support, ICU physicians and nurses; inhalation injury management, respiratory therapists and bronchoscope operators (Fig. 4b); venous pathway maintenance, an intravenous (IV) team consisting of a specialized catheter anesthesiologist and nurse (Fig. 4c); and infection control, a hospital infection control/surveillance specialist and antibiotic experts. Moreover, a multidisciplinary conference attended by these experts, department directors, and hospital leaders was held at 16:00 every day for team members to discuss and solve problems of the most critically injured patients (Fig. 4d).

(4) Logistic and material support was organized to ensure adequate supplies for intensive care. Both the hospital and government supported the clinical enterprise by acquiring the required drugs, equipment, instruments, plasma, and other blood products. Two operation rooms were exclusively assigned to the burn center, allowing us to conduct operations when needed.

The multidisciplinary approach proved to be invaluable during this campaign. This mechanism solved five life-threatening emergent events: one case of hypovolemic shock with massive bleeding caused by idiopathic thrombopenia (lowest platelet count $7 \times 10^9 \text{L}^{-1}$), two cases of septic shock caused by extended spectrum beta-lactamase-positive (ESBL+) Pseudomonas aeruginosa infections; one case of encephalopathy due to carbon monoxide poisoning, which induced severe cerebral edema and hernia; and one case of a paralytic ileum caused by acute cholecystitis.

![Fig. 3 - Emergency stage. (a) Life support team ready for incoming patients. (b) Diagram of the results of patient triage. (c) Implating a central venous catheter. (d) Bedside escharotomies. S AHU, Second Affiliated Hospital of Zhejiang University; ER, emergency room; HEICS, Hospital Emergency Incident Command System; CHAZU, Children's Hospital Affiliated to Medical College of Zhejiang University; BC, burn center; EC, emergency center; ENT, ear, nose, and throat department; ICU, intensive care unit.](image-url)
The respiratory team conducted 121 bronchoscopic examinations. At day 124, 18 of the 19 patients had stopped using ventilators and no serious respiratory infections were detected. The IV team maintained the fluid and drug lifeline via 107 central venous catheters, one peripherally inserted central catheter, and 80 detaining needles. The incidence of catheter-related bloodstream infection (CRBSI) was well controlled under the care of the IV team: The CRBSI rate of the first and second catheters were relatively high (5/21, and 4/18); after the efforts of the IV team, the CRBSI rate significantly dropped to 1/11, and 0 since the fifth catheter \(p = 0.013\) (Fig. 5a).

A total of 21 doctors and 50 nurses reinforced the main team in shifts, including nine doctors and 20 nurses from other hospitals. We purchased 250 packs of Polymyxin B from Hong Kong to treat the P. aeruginosa infections and two water jet systems (Versajet II Hydrosurgery System, Smith & Nephew GmbH, St. Petersburg, FL, USA) to facilitate debridement.

With the backup health-care workers on call, the burn team focused mainly on excision and graft procedures. A total of 89 operations were performed (53 in the first month, 25 in the next, and 11 in the last) (Fig. 5b). The area of patients’ residual wounds decreased significantly over time (48.3 ± 2.08% of TBSA at arrival, 10 ± 12.79% at day 30, 2.84 ± 5.82% at day 60, and 0.42 ± 1.39% at day 90) (Fig. 5c). After 124 days of extensive therapy, all of the patients’ wounds had healed, with 18 patients in rehabilitation. The 19th patient, the terrorist, was sentenced to death by the local court.

### 4. Discussion

In view of the 2008 Wenchuan earthquake and the 2003 SARS epidemic, many centers are now aware of the need to prepare for these unpredictable natural and manmade disasters.

Preparing future mass casualty events, regardless of the cause, is both necessary and beneficial for an institution and the region it serves [8–10]. In 2006, the International Society for Burn Injuries (ISBI) published guidelines for managing disasters involving large numbers of patients with severe burns [11]. The guidelines include a set of fundamental concepts for reference provided by medical personnel and government officials involved in disaster planning and management. It describes in detail the facilities, specialized burn teams, equipment, and facility–society communication needed to prepare for massive burn disasters.

Some authors have suggested establishing specialized burn wards or even specialized burn hospitals in most developing countries including China, where industrial and civil burn accidents are more common (especially small- and mid-sized ones) to prepare for possible massive burn disasters. However, in developed countries where specialized burn wards are dwindling, simulations and exercises during peacetime could both improve those plans and help the institutions and society prepare for possible massive burn disasters [12].

As described in our plan, burn disaster plans in the US, Europe, and Australia are set up and updated/improved with lessons drawn from major burn disasters. For regions in which a specialized burn ward is absent or overwhelmed, the core content of these plans are deployment of burn specialty teams (BSTs), burn assessment teams (BATs) and skilled burn teams (B-Teams). These teams are usually composed of burn surgeons, nurses, respiratory therapists, anesthesiologists, and intensive care specialists [13]. In the present case, SAHZU also established such an interdisciplinary team to conduct burn-centered intensive therapy. Later in 2014, SAHZU sent this team to Kunshan to help local hospitals treat the 150 severely injured victims of an accidental factory explosion.

For future disaster preparedness, it must be noted that the injury patterns of a bus fire attack differ significantly from those of other massive casualty events such as explosive attacks.

1. Unlike bomb-induced multiple injuries (mainly crushing injuries and penetrating trauma), in narrow, crowded, closed-space fires, such as the event described here, the burns are more extensive and a large percentage of those evaluated will have inhalational injuries.

2. In a bus fire, the inside is filled who cannot escape until a window is broken. The victims were completely engulfed in fire and smoke. Although the bus capacity limited the number of victims, their average total burn area, degree of inhalation injury, and proportion of severe burn were significantly greater than those seen in similar disasters, for example, the 2003 Rhode Island nightclub fire, the 1998 discotheque fire in Gothenburg, and the 1942 Cocoanut Grove fire [8,14,15].

3. Bus attacks are more likely to occur in crowded downtown areas, where spontaneous rescue attempts by untrained civilians may dramatically decrease the on-scene mortality. Lastly, almost half of the victims were retired tourists much older than the victims of the nightclub fires. Their preexisting chronic comorbidities may have been aggravated by the

### Table 1 – Basic information about bus passengers with severe burns treated in the hospital (n = 19).

| Cohort                        | Value |
|-------------------------------|-------|
| Gender                        |       |
| Male                          | 9     |
| Female                        | 10    |
| Average age (year)            | 40 ± 1.46 |
| Average % TBSA burn           | 48.3 ± 2.08% |
| <60%                          | 11    |
| 60–90%                        | 8     |
| >90%                          | 2     |
| Inhalation injury             |       |
| Mild (above glottis)          | 3     |
| Moderate (glottis-carina)     | 8     |
| Severe (below carina)         | 8     |
| Cardiac arrest                | 1     |
| Acute renal failure           | 1     |
| Basic chronic comorbidities   |       |
| Hypertension                  | 1     |
| Coronary disease              | 1     |
| Atrial fibrillation           | 1     |

TBSA, total body surface area.
injury, stress, and hypoxia of the fire, which may have interfered with the treatment.

Our institution benefited from the planning and performance of disaster drills.

1. The existence of an in-hospital broadcast and 24-h standby multidisciplinary life support team ensured quick response.
2. The hospital–government cooperation facilitated the rapid and accurate triage of patients to the appropriate hospitals. In the treatment stage, this mechanism also supplied us with adequate blood products, special drugs, and the needed equipment.
3. The burn-centered multidisciplinary teams and daily/interim consult conferences to treat the most critically injured patients were successful components of our disaster response. The highly efficient cooperation of these specialized teams allowed the burn surgeon to conduct 53 excision-and-graft operations within the first month, thus significantly reducing the incidence of wound-related infections. Five critical situations were successfully addressed with the consult conferences, with no in-hospital mortality.

Several areas of weakness became apparent during this disaster.

1. Because buses make several stops and have no security measures, these attacks are much more difficult to prevent than those on other forms of public transportation such as...
metro trains, airplanes, and railway trains. Therefore, to
prevent massive casualties in such burn disasters, it is
important to mobilize civilians to report and stop suspi-
cious persons before the attack, as well as to train drivers
and passengers to extinguish the fire and evacuate the
victims.
2. The golden period of emergency treatment for thermal
injury is critical for successful resuscitation of mass burn

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Fig. 5 – Results. (a) The CRBSI (catheter-related bloodstream infection) rate of the first and second catheters were relatively high (5/21, and 4/18); under the care if the IV team, the CRBSI rate significantly dropped to 1/11, and 0 since the fifth catheter. Logistic regression (catheter number to CRBSI) indicated an OR of 0.605 (95% CI (0.408; 0.898)), and a P-value of 0.013 indicated the direct impact of catheter number to the CRBSI rate. (b) A total of 89 operations were performed (53 in the first month, 25 in the next, and 11 in the last). (c) The area of patients’ residual wounds decreased significantly over time (48.3 ± 2.08% of TBSA at arrival, 10 ± 12.79% at day 30, 2.84 ± 5.82% at day 60, and 0.42 ± 1.39% at day 90).
casualties. However, public education has failed to inform civilians to triage the burn patient to the hospital with the largest and most advanced burn unit. Ten patients – more than half – were driven to the nearest hospitals without a burn ward, delaying treatment and subsequently requiring secondary triage. Therefore, the public should be educated on their responses to such circumstances.

3. We took 2 days to arrange the transfer of the original burn patients to a central hospital and to sterilize the burn ward for concentrated treatment of the bus attack victims. The ICU physicians were unfamiliar with postburn fluid resuscitation therapy, which may have contributed to the early renal failure of one patient with severe burns, who subsequently survived. The experience of this bus fire attack could help us address these shortcomings.

5. Conclusion

In conclusion, preparation, including planning and disaster drills, is crucial for managing future mass casualty events. Efficient and precise first rescue and triage can reduce the rate of prehospital mortality; a burn-centered multidisciplinary approach to treatment as well as a mechanism to facilitate cooperation between the hospital and government entities will help reduce the in-hospital mortality rate. The areas of weakness needing improvement are prevention and rapid evacuation of a bus fire attack, precise primary triage, and burn-specific resuscitation. Despite the casualties from this terrorist attack, the lessons drawn here can improve our preparedness for future disasters.

Authors’ contributions

Hu Hang collected and analyzed the data, and wrote the manuscript. Wang Jianan designed the study and the figures. Han Chunmao conducted the literature search and data interpretation.

Conflict of interests

The authors state that there are no conflicts of interest. No funding was received for this study. The corresponding author had full access to all the data in the study and had the final responsibility of deciding to submit for publication.

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