

Impact of London's Terrorist Attacks on a Major Trauma Center in London

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Abbreviations:

A&E = accident and emergency department
HEMS = Helicopter Emergency Medical Service

MCI = mass-casualty incident
MIP = Major Incident Plan
RLH = Royal London Hospital

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Abstract

During the morning rush hour on Thursday, 07 July 2005, a series of four bombs exploded, affecting London's public transport system. These terrorist attacks killed 52 people and injured >700. A major incident was declared, and the Royal London Hospital (RLH) was a primary receiving hospital.

A total of 194 patients presented to the RLH. Twenty-seven patients required admission. A total of 11 amputations were performed on eight patients. One patient died intra-operatively. Another patient died on Day 6 due to complications related to a head injury.

Coordination is vital to the implementation of the hospital's Major Incident Plan in such an emergency. Subsequent internal reviews of the response of the RLH on 07 July 2005 highlighted problems with communication and documentation, as well as the need for extra staffing. These areas should be improved for the management of future major incidents.

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Introduction

Mass-casualty incidents (MCIs) resulting from terrorist bombings pose special problems, create management challenges all levels of the medical system, and may overwhelm even the most experienced trauma center.¹

The objective of this study was to analyze the terrorist suicide bombings that occurred in London in July 2005, and the resulting hospital emergency response, in order to learn victim outcomes, resource utilization, critical events, and the time course of the emergency response.

Methods

This report is based on information obtained from hospital records, formal debriefings after the events, a major incident audit at the Royal London Hospital (RLH), and open-source documents. Open sources of information were obtained from the Websites by using the keywords "London bombing" and "medical response to terrorism". The following Websites were used: (1) <http://www.bbc.co.uk>; (2) <http://www.pubmed.gov>; and (3) <http://www.independent.com>.

Results

Events

On Thursday, 07 July 2005, a series of four bombs struck London's public transport system during the morning rush hour. At 08:50 hours (h) (British Summer Time (BST)) three bombs exploded within 50 seconds of each other on three London Underground trains in the vicinities of the Liverpool Street, Edgware Road, and King's Cross Stations. The final explosion occurred on a double-decker bus in Tavistock Square, not far from King's Cross, around an hour later. A timetable of the events of 07 July 2005 is provided in Tables 1, 2, and 3. Substantial misinformation was provided in the early stages following the explosions.

Time (h)	Event
08:50	Three bombs exploded on three London Underground trains: -Circle Line train between Liverpool Street and Aldgate Station. -Piccadilly Line train between Russell Square and King's Cross Station. -Hammersmith and City Line train at Edgware Road Station.
09:33	All London Underground services suspended—the London Underground Network said it was the result of a power fault across the network.
09:40	British Transport Police report power surge incident caused some explosions in the Underground at Aldgate, Edgware Road, King's Cross, Old Street and Russell Square stations.
09:47	A fourth bomb exploded on a Number 30 bus on Upper Woburn Place near Tavistock Square.
10:00	The National Grid, which supplies power to the Underground, confirms there had not been any problems with its system.
10:21	Scotland Yard confirms "multiple explosions" in London.
11:08	All bus services in central London suspended by Transport for London.

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Table 1—Chronology of events on 07 July 2005 (h = hours)

Time (h)	Event
09:07	HEMS alert
09:26	Major incident declared
10:10	First two casualties arrive, beds are cleared, and all elective surgery cancelled
10:30	23 walking wounded arrive at RLH
11:45	3 double-decker buses bring casualties to RLH; 95 casualties treated
12:40	Major incident cancelled

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Table 2—Chronology of events at the Royal London Hospital (h = hours; HEMS = Helicopter Emergency Medical Service)

Hospital Responses

Royal London Hospital's Helicopter Emergency Medical Service (HEMS) received a call of a "suspected incident" at 09:07 h. Forty minutes later, the "major" incident alarm sounded, and the Accident and Emergency Department (A&E) was closed to all non-major cases related to the incident. The RLH was designated as the primary receiving hospital for the victims of the bombings. The chronology of events at RLH is listed in Table 2. The HEMS dispatched 18 teams consisting of Medical Incident Officers in fast-response cars. Two doctors immediately were mobilized to Aldgate Station, and arrived at Aldgate Station at 09:31 h. The helicopter transported a team consisting of two doctors and two paramedics to Kings Cross Station. Another team was deployed by air to Edgware Road Underground Station. At 10:20 h, a team of two doctors and one paramedic arrived by a fast-response car at the scene of the bus explosion incident at Tavistock Square.

Medical Outcome

Twenty-six persons were killed on the Piccadilly Line train, 13 were killed on the No. 30 double-decker bus, and

13 were killed on the Circle Line train (Table 3). A total of 194 patients presented to the RLH. The Triage Team, consisting of an A&E registrar, a nurse, and a receptionist, were stationed at the ambulance entrance. The Outpatient Fracture Clinic was designated for the care of walking wounded. The most severely injured patients were received in the resuscitation room by multiple trauma teams, each consisting of: (1) a senior anesthetist; (2) a general surgeon; (3) an orthopedic surgeon; (4) an A&E medic; and (5) two nursing staff.

Twenty-seven patients required admission to the hospital (Figure 1). Seven required immediate transfer to the Intensive Therapy Unit and one was transferred to the High Dependency Unit. The remaining 19 patients required admission for head, neck, torso, and/or extremity injuries.

In total, 11 amputations were performed on a total of eight patients. The amputations performed were: (1) three below-the-knee; (2) five above-the-knee; (3) two through-the-knee with one converted to an above-the-knee; and (4) one below-the-elbow which was refashioned to an above-the-elbow amputation. Nine fasciotomies were performed (six on lower limbs and three on upper limbs). One patient died intra-oper-

Transport system	Traveling from	Traveling to	Time of explosion (h)	Number of persons killed
Piccadilly line train No. 311	King's Cross station	Russell Square	08:50 BST	26, plus the bomber.
Circle line train No. 204	Liverpool Street station	Aldgate	08:50 BST	7, plus the bomber.
Circle line train No. 216	Edgware Road station	Paddington	08:50 BST	6, plus the bomber
No. 30 double-decker bus	Upper Woburn Place	Tavistock Square	09:47 BST	13, plus the bomber

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Table 3—Description of the bombing attacks on London transport system (BST = British Summer Time)

atively and another died on Day 6 from complications related to a head injury.

The 167 walking wounded included 96 females and 71 males, with a mean value of their ages of 33 years (range 14–71 years). Thirty-nine patients had head, neck, facial, torso, abdominal, and/or extremity lacerations that required suturing. Seventy-eight patients required assessments for inhalation injury. Seventeen patients suffered with tympanic membrane perforation—eight bilateral, and nine unilateral. The walking wounded suffered included abrasions, head injuries, embedded foreign bodies, burns, and ankle sprains.

Communication Breakdown

Shortly following the attacks, the mobile phone networks across London failed, and the internal telephone lines became blocked due to the volume of calls being made. An additional 21,336 internal calls over the usual daily usage rate were made between 09:00 h and 14:00 h. As a result, there was a lack of information communicated from the scene of the bombings. Miscommunication was reflected in media reports.

The internal pager system also failed and went offline. Only two members of the Orthopedic Team, the lead orthopedic clinician, and the on-call trauma fellow, received an *air-call* alerting them to the major incident. An *air-call* is a message broadcast by selected pagers that, unlike the standard pager system, requires no action on behalf of the carrier of the pager in order to receive the message. There were difficulties initiating the Major Incident Plan (MIP) due to the communication problem. The lead orthopedic clinician was well-rehearsed in the major incident protocol and summoned the remainder of the Orthopedic Team, using the standard pager system and word of mouth to assemble in the outpatient clinic in order to treat the walking wounded. This latter action only was possible because at this early stage, there were no breakdowns in the communication lines.

As the events escalated, difficulties with communications increased. Communication between the A&E and operating theaters was not possible. Senior House Officers became runners liaising between the A&E and the operating theaters, which, although satisfactory, was a slow and

inefficient system. All the information carried by a runner was written on a piece of paper to prevent the delivery of inaccurate messages.

Staffing

Since the terrorists aimed to attack during the morning rush hour, the timing of the bombs caused the major incident to be declared at 09:00 h on a weekday, when the staffing levels at the RLH were at their highest. Had the bombings occurred an hour earlier, the hospital may not have been staffed to the capacity sufficient to deal with casualties of the major incident.

Additional staffing issues encountered stemmed from difficulty in contacting other departments based at separate sites within the hospital Trust. Like all hospitals in the UK, the RLH belongs to a group of hospitals collectively known as a *Trust*. Therefore, hospital policies are based on Trust-wide policies and apply to all hospitals within the Trust. Since all public transport in London was suspended, many off-site staff could not reach the RLH.

Documentation

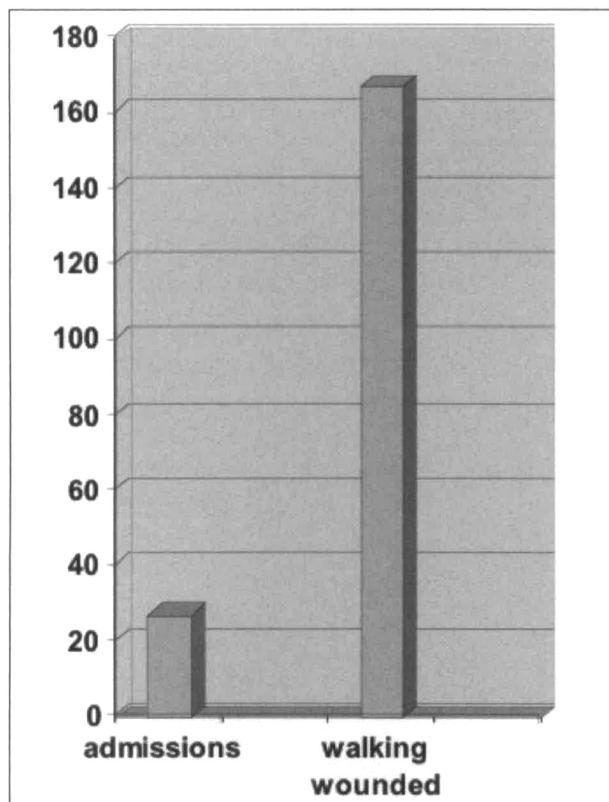
A large number of patients with varying degrees of injury severity arrived in a short period of time. This large number of patients resulted in problems with documentation and in obtaining information for the investigation.

The accurate and efficient allocation of hospital numbers is essential in this process. Although problems were resolved, the potential for serious clinical incidents was highlighted. Fortunately, one problem of duplicating hospital numbers was recognized. However, the risk of erroneous results and blood transfusion confusion errors are concerns in such situations.

Long delays in assigning patients with formal hospital numbers meant patients were not logged into the hospital Patient Administration System. Therefore, the results of urgent diagnostic tests, radiology reporting, and access to blood transfusions may have been subject to the possibility of delays.

Crowd Control

Photo identification cards facilitated access to the hospital by physicians and hospital workers.



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Figure 1—Number of admission and walking wounded patients

Command and Control

At the RLH, the orthopedic department became the nucleus of operational command. The department organized regular morning, afternoon, and evening trauma meetings in which all patients were presented and a plan of action was initiated. The multidisciplinary team involved orthopedic surgeons, general surgeons, neurosurgeons, plastic surgeons, accident and emergency medics, radiologists, anesthetists, and the theater management team.

Discussion

Communication is essential to prioritizing treatment and managing resources. Communication breakdown has been highlighted by other Trauma Centers during previous disasters.^{4,5} During the debriefing following the London bombings, participants expressed that a digital radio system could have overcome the communication problems faced during the response.

Clear demarcation is needed due to the risk of potential bio-hazard and cross-contamination caused by treating patients from four different explosion sites in the same hospital department. It is important to emphasize accurate documentation. Patient records should identify which incident site the patient was admitted from. This also would allow police and forensic staff to identify and trace individuals. Plans should include clearly labeling patients according to the disaster scene they arrive from and providing

segregated areas and medical staff to treat victims. Awareness should be raised of potential unexploded devices carried into the hospital either accidentally or on purpose.

Crowd control is essential during a MCI. Relatives and the bereaved usually are in pursuit of their family and friends. Patient identification cards can be coded with number and/or letter systems so public safety officials can identify patients and authorize relatives and/or the next-of-kin to enter treatment areas or hospital facilities. During a MCI, the overwhelming deployment of medical and technical resources creates chaos unless there is efficient leadership and allocation of resources.⁶

Thrice daily multidisciplinary meetings allowed personnel to focus on immediate problems as they evolved, and plan for the ongoing management of sick individuals whose conditions deteriorated. The meetings were held in an open area with the presence of senior members for all of the allied specialties (i.e., neurosurgery, intensive care, and plastic, cardiothoracic, vascular, and general surgery). The orthopedic department played a pivotal role in the coordinated multidisciplinary management. Senior members of the specialty medical teams played an active role in decision-making. This allowed management decisions to be streamlined. Beds were cleared by discharging patients in order to allow the bombing victims to be admitted.

Many injuries are missed following MCIs. Therefore, tertiary and quaternary assessments were performed by trauma teams in order to ensure all injuries were documented thoroughly. This proved to be beneficial, because injuries were not missed.

Conclusions

The RLH is the only Grade-I Trauma Center in London. Its long association with the HEMS has enabled an infrastructure to develop in which staff are used to dealing with high energy, trauma-induced injuries. A MIP had been developed to help to coordinate and optimize the Trust's response in dealing with large numbers of casualties. This response was tested rigorously by the numbers of patients presenting, compounded by the simultaneous arrival of three double-decker busloads of patients from the London Transport. These buses carried walking wounded victims from the Underground stations to the RLH. Overall, the MIP worked well.

The orthopedic department meetings became a focal point for all of the surgical specialties involved. Thrice daily multidisciplinary meetings were led by dedicated orthopedic trauma fellows, whose role was to perform regular surveys and liaise between the wards, intensive treatment unit, and operating theaters.

Some areas were highlighted where improvements can be made. Subsequent debriefings and internal reviews of the RLH's response on 07 July 2005 have highlighted a number of communication problems, which hindered the coordination of the hospital's response, problems with documentation, and the need for extra provision of staffing for future major incidents.

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