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FORENSIC FINDINGS FROM THE NAIROBI U.S. EMBASSY TERRORIST BOMBING
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FORENSIC FINDINGS FROM THE NAIROBI U.S. EMBASSY TERRORIST BOMBING

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ABSTRACT

Background: **The 1998 terrorist bombing of the US-Embassy in Nairobi resulted in the highest number of civilian deaths ever recorded from a single urban terrorist bombing in global history.**
Objective: **To present forensic findings from the Nairobi terrorist bombing and discuss some contributory factors to the high-fatality witnessed.**
Design: **Desriptive retrospective study.**
Setting: **Office of the Chief Government Pathologist of Kenya.**
Results: **A total of 211 persons were confirmed to have died as a direct result of the bomb blast. Out of the 201 cases examined in this paper, 198 (99%) died on the day of the blast. Sixty percent of the deceased were males and *85%* were aged between 21 and 50 years. Most of the deceased were visually identified (95%). The rest required fingerprinting (3%), DNA testing (2%), and forensic odontology (1%). Ninety six percent of the victims (194 cases) had primary blast injuries. The typical triad of blast fragmentation injuries was found in only 47% of the cases. Eighty nine percent (179 cases) had injuries in multiple anatomical regions. The most common cause of death was head injury (30%).**
Conclusion: **The anatomical pattern of injuries and other pathological findings among fatalities from this terrorist bombing are similar to those recorded from other bombing incidents worldwide. Contributory factors to the high fatality include the collapse of a densely populated building, the TNT-equivalent force of the bomb, the confined site of detonation, and probably the lack of a proper disaster response system.**

INTRODUCTION

Terrorism is the unlawful act of random and ruthless violence against property or individuals, usually innocent civilians, in order to intimidate governments or societies for political or ideological purposes (1). Bombing is involved in 80% of terrorist attacks because it is inexpensive to perpetrate and generates a large amount of publicity as well as fulfils the goal of terrorism (2). It is noted that in recent years, terrorist bombings have become increasingly common (2-5). Notable high-fatality civilian terrorist bombings that have been recorded in medical literature include the bombings in Bologna resulting in 84 deaths (6) Oklahoma City with 162 immediate deaths and five late deaths (7), Bali 184 deaths (8), Madrid 191 deaths (9) and London 56 deaths (10). Other high-fatality terrorist bombings were targeted at military installations such as at the 1969 bombing in Vietnam resulting in 46 deaths (11) and the 1983 bombing in Lebanon which had over 241 deaths (12).

BACKGROUND

On the morning of the August 7, 1998 a bomb detonated outside the rear entrance to the US Embassy building. The explosion occurred in front of a four storey building named Ufundi House, which was completely flattened by the bomb blast (Figure 1). The Ufundi House building was situated between the US embassy and a 22-storey Cooperative Bank building. The US Embassy and the Cooperative Bank buildings were heavily damaged by the blast. The bomb blast site is located near a busy intersection of streets adjacent to the main railway terminal of Nairobi. Several neighbouring buildings, including the Kenya Railway Headquarters opposite the embassy across the street, were devastated by the blast which shattered windows and blew off tiles from the roofs. The earth tremor resulting from the blast could be felt more than a mile away, and the blast was heard more than six kilometres from its epicentre.

This bombing in Nairobi is probably the worst single urban terrorist bombing in terms of number of fatalities to be witnessed in global history. Although it occurred more than seven years ago, there are bound to be important lessons to be learned from the incident as to why there was such a high fatality and the pattern of injuries sustained by the victims of the blast.

Terrorism continues to pose a huge threat to public safety. Despite the fact that there has been an escalation in large-scale terrorist bombings over the past decade, very little has been published in medical literature in terms of epidemiological analysis of forensic autopsy findings from these experiences (7-11). We are prompted to publish this paper with the hope of adding to existing knowledge on urban terrorist bombings that will be useful to medical as well as non-medical personnel involved in the war against terror as well as disaster management. In the paper, we document and relate forensic findings from this incident. Included is an analysis of forensic autopsy results, and a discussion of factors that contributed to the high fatality recorded. We hope the findings in this paper will reinforce calls and efforts towards improving preventive and responsive measures aimed at minimising fatalities from such incidents in future.

Figure 1

The cross (x) marks the point where the bomb detonated. The arrow points to the rubble of the collapsed four-storey Ufundi House. To its left is the US Embassy building and to the right is the 22-storey Cooperative Bank building (partly hidden). In front of the buildings is the busy Haile Selassie Avenue

MATERIALS AND METHODS

Design: Descriptive retrospective study.

Setting: The office of the Chief Government Pathologist and Head of Medico-legal services, Ministry of Health of Kenya.

Data Source: Physical files and computer records at the office of the Chief Government Pathologist. We retrospectively reviewed the autopsy reports and police records on the deceased. The police records are in form of official autopsy forms 23A documented by investigating police officers from the Criminal Investigation Department. The autopsy records are in form of computer word processing documents as recorded and stored by the authors since 1998. The first author was at the time a medical assistant to the second author who was at the time the Chief Government Pathologist of Kenya working under the Medico-legal Service Department (MLSD). Information regarding the circumstances surrounding the bombing, the bombing scene, and investigation by local and foreign law enforcement officers were obtained from unpublished official reports derived through personal communications and media reports.

Inclusion/exclusion criteria for autopsy cases: A bomb blast fatality was defined as any person whose death was directly related to the bomb blast as confirmed at autopsy by a qualified pathologist.

Details on autopsy examination done: The autopsies were performed by or under the supervision of the second author who is a specialist forensic pathologist. He was assisted in 41 cases by a general pathologist and a medical officer attached to the MLSD. Most of the autopsies (178 cases) were performed within one week of the bombing. The autopsies were done at various mortuary facilities, of which 97 cases were examined at City Mortuary, 41 at Kenyatta National Hospital, 31 at Chiromo Mortuary, 30 at Lee Funeral Home and two cases at Mater Hospital. As the norm, the doctors aided by autopsy technicians conducted all cases. The most common autopsy technique used was the Rokitansky method involving *in-situ* examination of the organ systems following standard skin incisions. Limited autopsy involving external examination only was employed in cases with extensive crush injuries, severe mutilating injuries or evisceration of thoracoabdominal organs whereby the external findings sufficed in arriving at a cause of death. Eight cases underwent external examination only due to religious objections to internal examination, nevertheless in these eight cases the external examination sufficed in determining the cause of death. Opinion by the examiner regarding cause of death was based on the most serious physical injury(-ies) likely to have caused death. The cause of death and all anatomical injuries documented were hand-written on the standard official autopsy form 23A which is routinely used at the MLSD.

Blast injuries: Physical injuries as recorded in the form 23A were reviewed by the authors and grouped into primary, secondary, tertiary and quaternary blast injuries defined as follows:

(i) *Primary blast injuries:* tissue injury as a result of the blast wave (barotraumas) e.g. blast lung and ruptured viscera, usually without any visible surface damage on the skin.
(ii) *Secondary blast injuries:* blunt or penetrating trauma caused by projectiles or fragments thrown by the blast wind e.g. abrasions bruises and lacerations.
(iii) *Tertiary injuries:* injuries caused by large objects (falling masonry) or the person being thrown by the blast wind e.g. crush injuries, amputations and fractures.
(iv) *Quaternary injuries:* burns and other effects of fire e.g. inhalation injuries.

Data tracking: Tracking of the data from respective sources was done using the 'police post-mortem number' and victims' names so as to avoid duplication. Data were kept strictly confidential with restricted access only to the authorised personnel from the Ministry of Health and the Police.

Data collection and analysis: Data were abstracted from the records above and transferred onto pre-coded data sheets, then entered into a computer database for computer analysis and preparation of descriptive statistics using Microsoft Excel® software. All but ten autopsy findings of persons known to have died as a direct result of exposure to the blast were analysed.

The ten excluded from the study were American citizens who for diplomatic reasons were not fully examined by the forensic pathologist in Nairobi.

Limitations and constraints: Due to existing logistical difficulties and the poor infrastructure in terms of forensic services and forensic documentation in Kenya and lack of a proper disaster response system at the time of the blast, several important details were not recorded by the recovery team which at the onset consisted largely of volunteers from the public and a few law enforcement officers untrained to handle such a task. Thus there was no record of the exact location from where bodies were recovered, the position of the bodies or whether the persons were alive or dead when recovered from the site.

RESULTS

Autopsy findings: A total of 211 persons died as a direct result of the bomb blast. Of these, 201 were examined by the Office of the Chief Government Pathologist, while the other ten were forwarded to the U.S. Government on diplomatic request. Of the 201 examined, 198 (99%) died on the day of the blast, one died on the third day after the blast while still trapped in the rubble and two died later while in hospital (29 days and 36 days post admission) from medical complications as a result of severe injuries sustained from the blasts. Based on signs of medical intervention seen at autopsy, at least nine victims were probably alive on arrival at the hospital emergency department (Table 1). Owing to the aforementioned limitations and constraints it was not possible to determine exactly how many persons died at the scene.

Gender, age and method of identification (Table 1): One hundred and twenty one of the dead were males (60%) and eighty were females (40%). Most of the dead victims were between 21 years and 50 years of age (85%). The exact age of three adults could not be determined, but there were no paediatric-age fatalities, however seven victims were below 21 years old, but above 16 years of age. In identification of the victims, 190 (95%) were identified through visual inspection by their relatives and friends and with the help of photographs. Seven cases (3%) required confirmation of identification by fingerprint examination, two cases required DNA identification in addition to the fingerprint examination while two other cases relied on DNA and dental (odontological) examination.

Table 1

Date of death, signs of medical intervention, gender, age and identification method

	No.	(%)
Date of death		
Day of blast (August 7, 1998)	198	99
Later (after August 7, 1 998)	3	1
Total	201	100
Signs of medical intervention		
Yes	9	4
No	192	96
Total	201	100
Gender		
Male	121	60
Female	80	40
Total	201	100
Age (years)		
<10	0	0
11 —20	7	3
21—30	57	28
31—40	69	34
41—50	42	21
51—60	21	10
>60	2	1
Unknown	3	1
Total	201	100
Identification method		
Visual identification	190	95
Fingerprinting	7	3
DNA analysis & fingerprinting	2	1
DNA analysis & dental records	2	1
Total	201	100

Anatomy of the injuries: distribution and pattern of occurrence (Table 2): In terms of anatomical distribution of the injuries, 178 persons (89%) had injuries involving multiple anatomical regions while 23 (11%) had single site involvement. In all, 177 (84%) persons had head injuries, 106 (50%) chest injuries, 71(34%) lower limb injuries, 58 (27%) upper limb injuries, 48 (23%) abdominal injuries and 46 (22%) injuries to the neck. With respect to the thoracic

diaphragm, 105 (52%) persons had injuries affecting both sides of the diaphragm, 91 (45%) had injuries involving the upper body alone, and only three (1%) had injuries below the diaphragm alone. In four cases, no physical anatomical injuries were noted on visual examination (negative autopsies). The most common anatomical combination or pattern of injury occurrence was 'head with chest injuries' seen in 35 cases (17%) followed by 'head injuries' alone in 17 cases (8%) and 'head with neck injuries' in 13 cases (6%). Of those with single site involvement, 17 died from head injuries, three from chest injuries, two from lower limb injuries, and one from neck injuries.

Table 2

Anatomical distribution of injuries

	No.	(%)
Number of anatomical sites		
Multiple	174	87
Single	23	11
No injuries seen	4	2
Total	201	100
Upper vs. lower body involvement*		
Both upper and lower	103	51
Upper only	91	45
Lower only	3	1
Unremarkable (no injuries)	4	2
Total	201	100
* With respect to the thoracic diaphragm		
Frequency of anatomical sites involvement in all cases		
Head	177	84
Chest	106	50
Lower limbs	71	34
Upper limbs	58	27
Abdomen	48	23
Neck	46	22
Trunk	25	12
Back	10	5
Whole body burnt	8	4
Whole body autolysed	1	<1

Pathological description of the injuries: type, occurrence and pattern (Table 3): In terms of pathological description of the injuries, 176 persons (90%) had evidence of primary and secondary blast injuries, 11 (50 %) persons sustained burns in addition to the primary and secondary injuries and six persons (6%) had tertiary blast injuries in addition to the primary and secondary blast injuries. Of note is that in four persons (2%) there were no remarkable injuries recorded (negative autopsies). In total, 194 persons (96%) had evidence of primary blast injuries. One hundred and ninety five persons (97%) had evidence of secondary blast injuries and seven persons (4%) had evidence of tertiary blast injuries. Of those with tertiary blast injuries, five had traumatic amputation of the limbs, and one had traumatic mid-abdominal transection across TI2 / LI vertebrae.

The most common specific forms of injuries resulting from the blast effects as seen were lacerations in 134 persons (67%), followed by bruises

Table 3

Injury description: type, occurrence and pattern

	No.	(%)
Injury type		
1º and 2º blast injury	176	87
1º and 2º blast injury with burns	11	6
1º, 2º and 3º blast injury	6	3
2º blast injury	2	1
1º blast injury	1	<1
Burns	1	<1
No injuries observed	4	2
Total	201	100
Tally of victims with specific injuries		
Lacerations	134	67
Bruises and abrasions	106	53
Skull fractures	57	28
Rib fractures	46	23
Fractures of extremity	38	19
Complex STI	19	9
Cavitations of skull	17	8
Visceral rupture / lacerations	11	5
Burns	9	4
Stab wound due to sharp object	6	3
Crush injuries	6	3
Evisceration	5	2
Whole body burnt (Incineration)	5	2
Large foreign body *in-situ*	4	2
Gouged eyes	3	1
Tongue protrusion	2	l
Mid-abdominal transaction	1	<l
Amputation	1	<1
Triad of fragmentation injuries	95	47

and abrasions 106 (53%) skull fractures 57 (28%). other bone fractures were mainly ribs (46%), fractures in the extremities 38 (19%) and complex soft tissue injuries in 19 persons (9%). Other injuries seen included cavitations of the skull 17 (8%), rupture of abdominal viscera 11 *(5%),* burns nine (4%), incised wounds six (3%) and crush injuries in six persons (3%).

The so called triad of blast fragmentation injuries consisting of abrasions-bruises-lacerations, occurring together, was seen in 95 persons (47%). This triad of fragmentation injuries was the only combination of injuries (injuries pattern) in 35 persons (17%), whereas in the remaining 60(30%), it occurred in association with other injuries.

Cause of death (Table 4): The Office of the Chief Government pathologist determined the most common cause of death from the terrorist bombing as head injury in 30%, multiple injuries in 25%, chest injuries in 17% and traumatic asphyxia (blast lung) in 15%.

DISCUSSION

This is the highest number of civilian deaths ever recorded from a single incident of urban terrorist bombing, and second in terms of single urban terrorist bomb fatalities to the 1983 bombing in Beirut that killed 241 military servicemen (12). Most of the victims in this bombing were innocent ordinary Kenyan civilians in the working class age group going about their usual daily businesses, whose lives were unjustly and indiscriminately cut short.

Factors leading to the high fatality: There are multiple mechanisms and determinants of type and severity of physical injuries from exposure to explosives (13-18). These have been reviewed in details in a recent paper by DePalma *et al* (19). The main determinants that often lead to high numbers of fatalities include a large TNT-equivalent force of explosion, explosion in a confined space such as buildings and collapse of a densely populated building.

Table 4

Cause of death

Cause of death	No.	(%)
Head injury	61	30
Multiple injuries	50	25
Head and chest injuries	34	17
Head and neck injuries	6	3
Head and abdomen injuries	4	2
Head injury and burns	2	1
Traumatic asphyxia with multiple other injuries	4	2
Chest injuries	34	17
Traumatic asphyxia (blast lung)	31	15
Exsanguination due to stab wound	14	7
Effects of fire	4	2
Negative autopsy (no anatomical cause of death found)	4	2
Septicaemia	2	1
Abdominal injuries	1	1
Total	201	l00

The bomb in Nairobi has been estimated by experts from the Kenya Police Force and the American Federal Bureau of Investigation (FBI) to have had a TNT-equivalent force of about 1000 Kg (unpublished reports). In comparison, the 1983 bomb in Beirut had a 5455 Kg of TNT-equivalent force (5). The 1995 bomb in Oklahoma, which caused 162 immediate deaths and five later deaths, composed of more than 1814 kg of TNT-equivalent force (7).

We believe the total collapse of the Ufundi House was the major contributing factor to the high fatality witnessed in this bombing. Unfortunately, we lacked the necessary data regarding exact location of the deceased and survivors at the time of the bomb blast site that would have enabled us to make a more conclusive comparative analysis for derivation of fatality rate in terms of the victim's location in specific buildings or street sections. However, as shown in the Oklahoma bombing, persons located in a collapsed building or collapsed parts of a building, especially those in upper floors, are more likely to die than those in buildings or sections that are not collapsed (3). Collapse of buildings and structures has also been a major factor that explained the greater incidence of casualties and fatalities resulting from various bombings such as in Bolognia and Beirut (5-7,12-19).

The TNT-equivalent force of the Nairobi bomb played a big role in terms of the explosive effect that caused the collapse of the Ufundi House which was in close proximity to the detonation site. In addition, the Ufundi House building was worst hit by the blast because it lay between the two buildings, which reflected and concentrated the blast wave onto it. Thus the proximity of the detonation site to the building and the semi-closed environment in which the explosion occurred also contribute significantly to the explosive damage to buildings. It has since been determined by government authorities in Kenya that the Ufundi House was not of sound structural integrity (personal communications). The weak structure of the building and its inability to withstand the effect of the blast were thus the key factors that led to its collapse in contrast to the US Embassy and the Cooperative Bank buildings which remained upright.

The timing of the blast coincided with a busy weekday morning when the Ufundi House which had several colleges and offices, as well as the embassy itself and the Cooperative Bank building were full of people. The streets were also very busy at the time. The explosion occurred at a busy intersection of two major streets (Haile Selassie Avenue and Moi Avenue), near a busy bus terminus that is outside the main railway station (Kenya Railways Headquarters). These factors certainly contributed immensely to the high fatality and overall casualty rate as there were many people exposed and in close proximity to the blast. The semi-closed environment also contributed to the high fatality witnessed. Recent reports published in medical literature have addressed the more devastating effects of explosions in enclosed environments compared to open-spaces (20,21). Investigations revealed that it was indeed the motive of the terrorists to detonate the bomb from within the basement of the US-Embassy building but a road barrier manned by security officers prevented their access to the basement. Were this to happen, the confines of the basement parking would have tremendously augmented the destructive effect of the blast and led to even higher fatalities.

The US Embassy in Nairobi has since been moved out of the city centre. Overall, there have been attempts by the concerned authorities to relocate high-risk terrorist targets away from densely populated areas. Other public safety measures being introduced include redesigning of curb-walks and building entrances, restriction of access to parking near buildings and strict security surveillance as anti-terrorist measures. This paper re-emphasises the need for such measures, which should be strengthened to proactively deter terrorist acts and at the very least to minimise the effects of terrorist acts on civilian lives.

Blast injuries: The findings presented in this paper illustrate that anatomical pattern of injuries resulting from terrorist bombings have been somewhat consistent. The specific anatomical injuries most commonly found among bomb fatalities are head injuries followed by injuries to the chest and abdomen. These injuries are also the most common causes of death in all other forms of non-blast trauma, which may be a reflection of the tolerance of these body systems to severe injuries *(22-25)*. From other incidents, it has been documented that head injuries is the most common single contributor to both immediate and late fatalities resulting from bomb blasts, contributing to 71.4% of immediate

deaths from data on 234 fatalities in the Beirut bombing and 53% of all deaths not due to multiple injuries in the Oklahoma bombing. Pulmonary blast injuries was the most common form of thoracic trauma found in immediate fatalities and was the most common cause of immediate death from data on 395 fatalities in Northern Ireland (47%), followed by abdomen and chest (34% and 25% respectively) (5). In the Oklahoma bombing, the cause of death among all fatalities was multiple injuries 73% followed by head trauma (14%), chest trauma (8%), head and neck trauma (2%), traumatic shock (2%) and fractured cervical spine (1%) *(7)*. The variations in terms of regional distribution of injuries seen in this bombing in contrast to other high-fatality incidents probably relate to the environment in which the blast occurred, type and size of the blast, proximity of the victims to the blast, effects of environmental pressure changes and condition caused by blast overpressure and blast wind (14-18).

The types of injuries witnessed among fatalities from this bombing in Nairobi traverse the entire range of blast injuries that follow bomb blasts. Four deceased whose bodies were recovered at the bomb blast site did not have any evident physical injuries or apparent anatomical cause of death. These were termed negative autopsies but classified as having died from effects of the bomb blast owing to the circumstantial findings and history from the investigating police officers. It has been noted in medical literature that occasionally victims may be found dead at the scene, with no observable fatal injuries (19,26,27). The terms 'shock' or 'lethal reflexes' have been used as a cause of death, but it remains questionable whether they actually occur as some of these deaths may be due to embolism (27).

Disaster preparedness: At the time of the bombing, Kenya did not have any semblance of a structured disaster response team. It was evident that immediately after the explosion there was no coordinated response to the bombing in terms of rescue and recovery efforts. At autopsy, only nine of the deceased who died on the day of the blast had any signs of medical intervention. Some of the deceased died from injuries that if promptly and properly managed would have averted death. These include 14 who died from haemorrhage following penetrating wounds and at least two confirmed cases of death at the bomb blast site trapped in wreckage several hours after the blast had occurred. Unfortunately due to lack of proper recording during the rescue and recovery efforts, it was not possible to ascertain the exact number of patients who may have been saved through appropriate intervention. Proper disaster management response planning backed with adequate medical services and relevant infrastructural support such as transport and communication systems have been shown to be of utmost importance in reducing the fatality rate following terrorist attacks (3,5,9,12).

Victim identification: In this incident, visual identification of deceased sufficed in 95% of the cases and advanced forensic techniques such as odontology and DNA analysis were only required in a few cases. Previous reports indicate that most bomb victims are identifiable by visual inspection but mistakes can be made when stressed relatives make wrong identification (1,5,7) . Difficulty in identification is likely in cases of severe mutilation or disruption, particularly involving the head, or when distinctive clothing is greatly altered by impregnation with plaster and grit. In cases of difficulty, one may turn to fingerprints, peculiar scars and tattoos before resorting to DNA analysis which is often expensive. Forensic odontology is limited by lack of proper antemortem dental record in our setting.

In conclusion, the pathological findings presented are very similar to previously described findings among fatalities from other major bomb blast incidents. They illustrate that urban terrorist bombings result in a consistent pattern of injuries among fatalities, differing only in terms of scale and severity. The main contributory factors to the high mortality as discussed include the collapse of a densely populated building, the size of the bomb, the confined site of detonation, and the lack of a proper disaster response system. Appropriate measures to minimise fatalities from terrorist urban bombings is a challenge that should be addressed through ways that minimise exposure of persons to the blast wave, decreasing the likelihood of building or structural collapse and efficient coordination of disaster response mechanisms.

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