Int J Legal Med (1999) 112 : 372–375

CASE REPORT

B. Karger · R. F. Zweihoff · A. DuChesne

Injuries from hand grenades in civilian settings

Received: 28 May 1998 / Received in revised form: 10 August 1998

Abstract Four cases of hand grenade detonations in civilian life with homicidal intent are reported. The detonations always occurred in close proximity to the victims but there were only two fatalities out of seven victims directly attributable to the hand grenades. The relatively low mortality rate results from the ballistic characteristics of hand grenade missiles such as low mass and sectional density. This leads to rapid deceleration and thus to a poor penetration capacity of intermediate targets and tissue. Window glass at a distance of 2 m was not perforated in one case and the vast majority of fragment wounds showed a short wound tract of small diameter. The potential for physical activity can be unaffected even after a detonation inside a car. However, body parts almost in contact with the hand grenade, such as in a struggle, suffer large lacerations and comminuted fractures. At a distance, the chance of striking a vulnerable body region is increased by the multiple missiles but the wounding potential clearly decreases with increasing distance due to rapid deceleration and decreasing fragment cloud density. The effective range of detonation shock waves from hand grenades is very short and can only contribute to wounding in close-to-contact detonations. The forensic reconstruction is based on the directed radial character of the forces generated and on the sharply decreasing intensity of these forces with increasing distance from the detonation.

Key words Detonation · Hand grenade · Multiple missiles · Ballistics · Homicide

B. Karger (✉) · A. DuChesne
Institute of Legal Medicine, University of Münster,
Von-Esmarch-Strasse 62, D-48149 Münster, Germany
Fax +49 251 8355158

R. F. Zweihoff
Institute of Legal Medicine, Bünnerhelfstrasse 31,
D-44379 Dortmund, Germany

Introduction

Hand grenades are military explosive devices which basically consist of a trigger and safety mechanism, a primer, a time fuse, a detonator, explosive, missiles and a case. Two types of hand grenades can be distinguished with regard to the missiles. One version uses a large number of steel or lead spheres inside a plastic case. The other type has a metallic body frequently showing predetermined breaking points. The detonation shatters the body and thus produces numerous small and mostly irregular fragments ("fragmentation hand grenade"). The detonation of a hand grenade in civilian life (Echsel 1989; Gerling and Pribilla 1989; Biermann and Heinze 1995) is an extraordinary event in western European countries but the frequency clearly increased in our Institutes during the last decade, which is probably due to the increased availability of hand grenades of eastern European origin. Reports from the military sector (Robson 1983; Adams and Fackler 1990) are also rare but military settings differ from civilian life. The wounding potential of different hand grenades relative to the distance from the detonation and other ballistic factors can be of importance for the forensic evaluation as well as for possible police actions such as in a hostage situation. Therefore, four selected cases of hand grenade detonations in typical civilian settings are reported and the terminal ballistics are discussed.

Case reports

Case 1

A Chinese hand grenade type 86 P (weight approx. 290 g, approx. 1600 steel spheres 2.5–3.0 mm in diameter) wrapped in a red blanket was detonated in the course of a marital quarrel in the bedroom. At the time of detonation, the wife was lying on the bed in a prone position and the husband, who had acquired the grenade during "Operation Desert Storm", was kneeling or lying on her back. The hand grenade was located below the wife's right clavicle so that the torso of the man was protected by the body of his wife. Both hands of the wife and the right hand of the husband were in close proximity to the hand grenade, apparently because both were

fighting for it. The detonation produced multiple holes and a crater in the mattress measuring 20 × 20 cm but the slatted wooden bed frame did not show complete perforations. Abundant blood stains and red fibres from the blanket were present on the ceiling and the walls. This stain pattern was radially arranged around a centre marked by the crater of the mattress. A double-glased window at a distance of 2 m showed multiple hits with perforations of the first but not of the second layer (Fig. 1).

The woman died at the scene. Autopsy revealed the following injuries: a large and irregular but mostly shallow laceration of the right anterior upper chest wall (Fig. 2) surrounded by detonator and explosive residues. The soft tissues of the left chest showed several small tangential wounds. The second and third ribs were extensively fractured and the right pleural cavity was opened. Both lungs, the pulmonary artery, the right atrium, the aortic arc and the large cervical vessels showed multiple small defects of circular to slit-like shape and a bilateral haemopneumothorax was present. The soft tissues of the right face were lacerated and the mandible and the nasal bone were fractured but the neurocranium was not perforated and the brain was not injured. The right hand was amputated at the wrist and the left hand was lacerated with multiple steel spheres inside the tissue. Multiple spheres were also found in the soft tissues of both upper arms and in the right hip region. Death was due to hemorrhagic shock.

The man survived with a laceration of the right hand including metacarpal fractures and amputation of several fingers, which necessitated surgical amputation at the wrist. Multiple steel spheres were present in the soft tissues of the head without fractures, in the left forearm with fracture of the ulna (Fig. 3) and in the left thigh.

Case 2

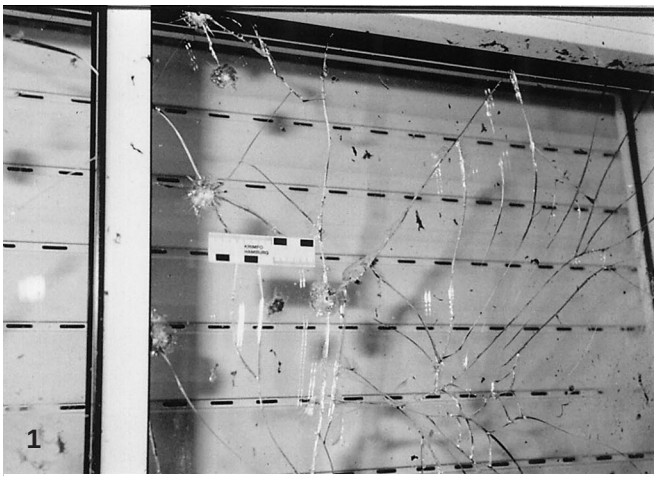
During a violent dispute in the field of organized crime, a fragmentation hand grenade M52 P3 (Fig. 4) of Yugoslavian origin was thrown into a car, VW Golf, through the open window and detonated between the front passenger door and the passenger seat. Of the three occupants of the car, the surviving driver was able to escape from the scene, the rear passenger received an additional gunshot and the front passenger was able to leave the car but was killed by a gunshot to the head. Finally, the assailants set the car on fire.

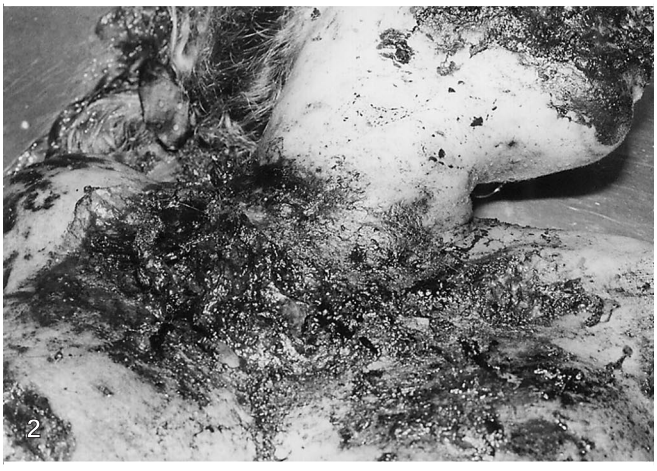
In addition to heavy burns and a tangential close-range shotgun injury to the back, the rear passenger had only two groups of fragment injuries. One large and four small fragments had entered the outer aspect of the right thigh and were recovered from the gluteus muscle. Two small fragments had entered below the right costal arch; one of these penetrated the lung only 1 cm in depth while the other one was located in the intercostal muscles. A slightly elevated carbon monoxide level in the heart blood (CO-Hb 15%) indicated that the man was still alive when the fire started. The front passenger died from the gunshot to the head. The right foot and lower thigh were severely lacerated with comminuted fractures and multiple fragments in the tissue. One thin fragment of the grenade almost 2 cm in length was recovered from the right upper thigh. The surviving driver merely had fragment injuries of the soft tissues of the right leg (no exit).

Case 3

A man killed his mother-in-law with a hand grenade M75 (Yugoslavian origin, 37 g PETN, approx. 3000 steel spheres 2.5–2.9 mm in diameter) or a copy thereof. After removal of the safety pin, he inserted the grenade into a tightly fitting parcel. The wall of the parcel pressed the safety lever so that the firing pin was fixed. The woman opened the parcel, which allegedly contained a Christmas gift, while sitting on a sofa. At the moment of the detonation, the parcel was located on the sofa to the right side of the woman, who was looking into it.

Autopsy showed multiple small, slit-like to circular skin defects to the right side of the trunk, both arms and hands and the right upper thigh. The wound tracts were short and thus exit wounds existed only where thin layers of tissue were involved. The right index finger was lacerated. Multiple spheres were found in the muscles of the right chest but the pleura and lungs were not injured. A few spheres had perforated the peritoneum but no injuries to organs or blood in the abdominal cavity were present. In addition, a 20 × 17 mm fragment of the body of the grenade had caused a





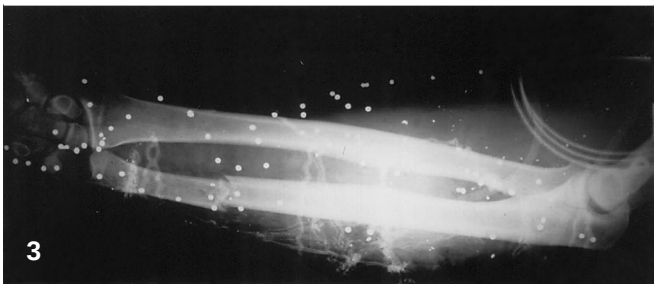


Fig. 1 The double-glased window located at a distance of 2 m from the detonation (case 1). Several missiles perforated the inner but not the outer layer. Patterns similar to a spider web from non-penetrating impact of spheres are present in both layers

Fig. 2 The wide soft tissue defect in the chest of the woman from a near contact detonation (case 1). Multiple small perforating injuries originate from the bottom of the crater which is shallow in the outer aspects and abundant explosive and detonator residues are present

Fig. 3 Radiograph of the left forearm of the man (case 1). Multiple small steel spheres are present in the soft tissues and the ulnar bone is fractured

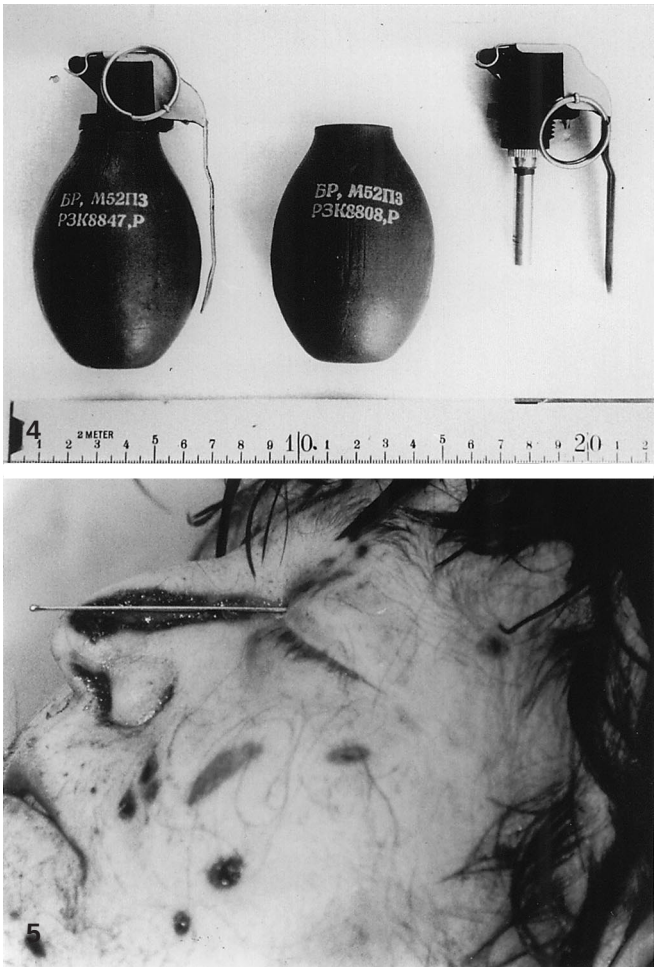


Fig. 4 Yugoslavian fragmentation hand grenade M52 P3 (weight approx. 460 g, 97 g TNT) used in cases 2 and 4. Left: complete hand grenade. Right: body and ignition/time fuse mechanism

Fig. 5 The face of the woman in case 3 showing superficial abrasions and small perforating injuries. The probe marks the trajectory of the sphere wounding the left frontal lobe with a graze injury of the nose and perforations of the left eye and the thin roof of the orbital cavity

large defect of the skin and peritoneum and was found close to the transverse colon. The face showed multiple small and mostly superficial defects. However, one sphere had perforated the left eye (Fig. 5), the thin base of the anterior cranial fossa and the left frontal lobe causing a wound tract 5–6 mm in diameter. Two more spheres taking a similar course had also perforated the base of the skull but did not enter the brain. Signs of expressed swelling of the brain and small blood aspiration foci in the lungs were present. The woman was found dead 15 h after the detonation and death was due to elevated intracranial pressure.

Case 4

A man left his home in his Mercedes Benz 300 TD and three detonations occurred after driving a distance of approximately 250 m. Unknown persons had attached three hand grenades M52 P3 (Fig. 4) to the underside of the car. A metal plate carrying the hand grenades was screwed to the underside below the driver`s legroom. The three safety pins were connected to a long wire, which was tied around the right front wheel. When the car started to move, the wire was wrapped around the wheel hub and eventually pulled the safety pins. However, the force was sufficient to detach two of the hand grenades from the metal plate. Consequently, these two hand grenades dropped onto the street and detonated behind the car causing small craters in the asphalt. The third hand grenade detonated as planned and produced a hole of approximately 20×20 cm in the underside of the car.The left foot and lower leg of the driver showed soft tissue lacerations with multiple fragments and fractures. Amputation of the foot was prevented by repeated surgery.

Discussion

Contrary to the military sector, hand grenades in civilian cases typically detonate very close to the victim (cases 1, 3), inside a confined space of small volume (case 2) or in contact with a barrier to be perforated (case 4). These close-to-contact situations put the victim at high risk but there were only two fatalities out of seven victims due to the detonations. This surprising finding can be explained by the ballistics of hand grenade fragments. Hand grenades contain approximately 30–160 g of detonator such as TNT or PETN and produce several hundred to several thousand missiles. The mass, calibre and shape of the missiles is predetermined in the case of steel or lead spheres, which commonly weigh less than 200 mg and have a diameter of 1–4 mm (Hogg 1990; HLKA 1993). The size of most fragments from fragmentation hand grenades varies considerably from minute to several mm in diameter and the shape is mostly irregular (Echsel 1989; Adams and Fackler 1990; HLKA 1993). The initial velocities of the missiles vary even in a single detonation. Approximate initial velocities of 200–600 m/s for spheres and of 400–1300 m/s for fragments have been recorded (HLKA 1993). However, when compared to bullets, the spheres and fragments have a low mass, a low sectional density and an unfavourable shape with regard to aerodynamics. Consequently, the retardation of hand grenade missiles in air and especially in dense media such as tissue or intermediate targets is considerable (Mendelson and Glover 1967; Wang et al. 1988; Adams and Fackler 1990; Coupland 1993; Bowyer et al. 1996).

In external ballistics, this results in a low “effective range” (Adams and Fackler 1990; HLKA 1993) and in a poor penetration capacity of intermediate targets. In case 1 glass was not perforated at a distance of 2 m (Fig. 1) and in case 2 the car seats and other interior projections apparently absorbed most of the fragments. Fragmentation protective vests stop hand grenade missiles reliably (Adams and Fackler 1990; Roberts and Bullian 1993). In wound ballistics, these characteristics lead to a limited penetration depth and to small wound channels with little bruising or tearing of tissue (Mendelson and Glover 1967; Georgi et al. 1991; Adams and Fackler 1990; Coupland 1993; Bowyer et al. 1996). Therefore, the vast majority of injuries observed in the seven victims were penetrating (no exit) with clean-cut wound channels of small diameter and only one intracerebral fragment was present in the three victims receiving multiple fragment injuries to the face (cases 1 and 3). Only direct injury to essential organs

or large vessels will pose an immediate threat to life. This occurred in cases 1 and 3 while in case 2, even a considerable potential for physical activity was present in at least two of the three car occupants. But hand grenades can of course be effective at longer distances if only one fragment happens to strike a vulnerable body region. This is illustrated by a case where a fragment perforated the seam of a fragmentation protective vest from a distance of several metres and injured the carotid artery causing exsanguination (Adams and Fackler 1990).

Detonation shock waves from conventional hand grenades have a low effective range: pressure recordings performed outdoors with different models at a distance of 7 m resulted in peak pressures of 2.6–4.5 kPa (HLKA 1993) whereas relevant blast injuries such as pulmonary contusion require approximately 100 kPa (Rawlins 1978; Bowen and Bellamy 1988; Mellor and Cooper 1989). The large lacerations, comminuted fractures and traumatic amputations analogous to anti-personnel mines (Coupland and Korver 1991) described in cases 1 and 2 only occur in contact or close-to-contact situations and are probably due to a combination of multiple missiles and the shock waves. The large hole in the underside of the car (case 4) was also produced from contact but in case 1 window glass and a mirror were not affected by the pressure. Since the fragment cloud density is very high close to the detonation, detonation shock waves represent an additional wounding mechanism of limited importance. This also explains why the wounding effects were not increased by a confined space such as a car (case 2). If heavier charges are used, reflections and enlargements of the detonation shock waves increase the chance of blast injury (Cooper et al. 1983; Katz et al. 1989; Leibovici et al. 1996).

The forensic reconstruction is based on the directed character of the forces generated by hand grenades and on the sharply decreasing intensity of these forces with increasing distance from the detonation (Rajs et al. 1987; Marshall 1988; Biermann and Heinze 1995). This frequently causes a radial and/or linear distribution of the resulting injuries, destruction patterns and traces. The point of convergence of the radial lines marks the point of detonation. In case 1, the tangential injuries of the woman's chest and the radial pattern of blood and fibres on the walls and ceiling clearly marked the location of the hand grenade as did the distribution of the injuries in cases 2 and 3. Since the maximum destruction is always located around the point of detonation, this site is marked by wide tissue defects (cases 1,2,4) or by crater-like destruction of the underlying material (cases1,3,4).

References

Adams DB, Fackler ML (1990) Grenade fragmentation injuries. J Trauma (China) [Suppl] 6:48–52

Biermann TW, Heinze G (1995) Rekonstruktion des Explosionsortes einer Handgranate auf einem Fahrzeugsitz. Arch Kriminol 196:105–113

Bowen TE, Bellamy RF (1988) Emergency war surgery. United States Department of Defense, Washington DC, pp 74–82

Bowyer GW, Cooper GJ, Rice P (1996) Small fragment wounds: biophysics and pathophysiology. J Trauma 40, Suppl:S159-S164

Cooper GJ, Maynard RL, Cross NL, Hill JF (1983) Casualties from terrorist bombings. J Trauma 23:955–967

Coupland RM (1993) Hand grenade injuries among civilians. JAMA 270:624–626

Coupland RM, Korver A (1991) Injuries from antipersonnel mines: the experience of the International Committee of the Red Cross. BMJ 303:1509–1512

Echsel H (1989) Untersuchungen über das Flugverhalten von Handgranatensplittern und ihre schockauslösende Wirkung am Menschen. Beitr Gerichtl Med 47:601–613

Georgi BA, Massad M, Obeid M (1991) Ballistic trauma to the abdomen: shell fragments versus bullets. J Trauma 31:711–715

Gerling I, Pribilla O (1989) Ungewöhnlicher Tod im Wasser. Arch Kriminol 183:163–167

HLKA (Hessisches Landeskriminalamt) (1993) Auswertung der Sprengversuche mit Handgranaten. Wiesbaden

Hogg IV (ed) (1990) Jane's infantry weapons, 16th edn. Jane's Information Group, Coulsdon, UK, pp 570–638

Katz E, Ofek B, Adler J, Abramowitz HB, Krausz M (1989) Primary blast injury after a bomb explosion in a civilian bus. Ann Surg 209:484–488

Leibovici D, Gofrit ON, Stein M, Shapira SC, Noga Y, Heruti RJ, Shemer J (1996) Blast injuries: bus versus open-air bombings – a comparative study of injuries in survivors of open-air versus confined-space explosions. J Trauma 41:1030–1035

Marshall T (1988) A pathologist's view of terrorist violence. Forensic Sci Int 36:57–67

Mellor SG, Cooper GJ (1989) Analysis of 828 servicemen killed or injured by explosion in Northern Ireland 1970–84: the Hostile Action Casualty System. Br J Surg 76:1006–1010

Mendelson JA, Glover JL (1967) Sphere and shell fragment wounds of soft tissues: experimental study. J Trauma 7:889–914

Rajs J, Moberg B, Olsson JE (1987) Explosion-related deaths in Sweden – a forensic-pathologic and criminalistic study. Forensic Sci Int 34:1–15

Rawlins JSP (1978) Physical and pathophysiological effects of blast. Injury 9:313–320

Roberts GK, Bullian ME (1993) Protective ability of the standard U.S. military personal armor system, ground troops (PASGT) fragmentation vest against common small arms projectiles. Mil Med 158: 560–563

Robson DC (1983) Death from an anti-personnel grenade explosion. J R Army Med Corps 129:115–116

Wang Z, Tang C, Chen X, Shi T (1988) Early pathomorphologic characteristics of the wound track caused by fragments. J Trauma [Suppl] 28:S89–S95