Rubber Bullet Injury

Case Report With Autopsy Observation and Literature Review

Masahiko Kobayashi, MD, PhD, and Paul F. Mellen, MD

Abstract: Rubber bullets are one of the less-lethal (nonlethal) weapons, which are increasingly used to incapacitate dangerous individuals, avoiding use of firearms. An autopsy examination of a man who was shot with improved rubber bullets revealed that the bullet caused pulmonary contusion. The bullet was 30 g in weight and consisted of a sponge foam nose with 40-mm diameter and a plastic body. He was not incapacitated and died of suicidal gunshot wound. The case raised a question as to how severe an injury is necessary to deter a person without causing death. A variety of rubber bullets have been used in the world, and they have occasionally produced severe or lethal injuries. A review of the literature demonstrated that the feature of injuries appeared to be related to the type of missile. It becomes more important for a forensic pathologist to be familiar with rubber bullets and injuries caused by them as the use of less-lethal weapon increases.

Key Words: rubber bullet, less-lethal weapon, nonlethal weapon, injury

Case Report

A 36-year-old white man with a history of depression and substance abuse assaulted and threatened several persons for unknown reasons with 2 firearms and an inert hand grenade. After his attempt to take a hostage, there was a police standoff. He was agitated, combative, and encouraging police to shoot and kill him. The police attempted to subdue him with a “rubber bullet” consisting of a sponge foam round nose with slightly rough surface and a plastic body (Fig. 1A). The projectile measured 40 mm (1.6 inches) in diameter and weighed 30 g. The SWAT team shot him with 2 rubber bullets, which struck the right upper chest and right upper arm through his T-shirt. The bullets were fired with a launcher (Fig. 1B) directly from approximately 8 m (25 feet) away. The velocity upon impact was estimated at approximately 95 mps (310 fps) and the kinetic energy was approximately 135 J (100 ft/lbs) according to the specifications provided by the manufacturer. Even after he was shot by the 2 bullets, he kept standing and shot himself on the left side of his head with his semiautomatic pistol.

The autopsy examination of the 182-cm (72-inch), 100-kg (220-lb) man showed a contact gunshot wound on the left side of the head and an exit wound on the right side with injuries including perforation of the calvarium and the brain. There were a circular, desiccated abrasion on the right upper chest (Fig. 2A) and a semicircular abrasion on the right arm (Fig. 3) caused by the 40-mm sponge foam bullets. The internal injury of the chest consisted of a circular pulmonary contusion (Fig. 2B) and soft tissue hemorrhage, but no rib or sternal fracture was found. Toxicologic testing showed he had been using cocaine, oxycodone, and alcohol. The cause of death was listed as a gunshot wound to the head, and the manner of death was classified as suicide.

DISCUSSION

The Case Presented and the 40-mm Rubber Bullet

The injuries of the anterior chest and right arm were consistent with injuries caused by the rubber bullet shown in Figure 1. Considering the relatively small weight of the bullet and the purpose of the less-lethal weapon, we had an impression that the pulmonary contusion was unexpectedly severe. It is reasonably assumed that the bullet could have caused other types of major injury, such as contusions of the heart, liver, and spleen. Impact on the chest may...
have induced commotio cordis in young persons. The eye or stomach with contents could have been ruptured, being susceptible to such impacts.

Although the 40-mm bullet produced the internal organ injury, it did not incapacitate him. The potency of a less-lethal weapon can be questioned either when it causes major injuries or death of the target or when it is not effective on the target. It is difficult to determine how severe the injury should be to incapacitate a person without causing serious injuries or death.

Suyama et al reported 11 cases with injuries caused by the same type of 40-mm rubber bullet. The literature demonstrated this bullet could cause lacerations as well as contusions. The slightly rough surface of the sponge foam can cause strong traction of the skin, resulting in lacerations, if the projectile strikes the skin at acute angle.

A lethal case by the same rubber bullet was reported in the State Inspector General’s review of a shooting incident at a California state prison. Reportedly, an inmate was shot during a fight with the same type of rubber bullet from the distance of approximately 53 feet (16 m). The bullet produced a 2.5-inch (5-cm) laceration on his forehead with bleeding, and he knelt to the floor. However, he quickly stood up and remained combative and agitated. He lost consciousness 1 hour later and died 47 days later due to intracranial trauma. The officer who shot him stated he had fired the launcher to strike the target on the lower extremities, but the bullet struck his forehead. Although the details of injury were not mentioned in the report, the rubber bullet caused laceration and intracranial injury, which resulted in the inmate’s death. The case review

FIGURE 1. Projectile of the 40-mm “rubber bullet” (A, B) and the launcher (B).

FIGURE 2. Rubber bullet injury of the chest. Circular, desiccated abrasion of the skin (A) and circular pulmonary contusion (B).

FIGURE 3. Semi-circular abrasion of the right arm.
<table>
<thead>
<tr>
<th>Report</th>
<th>Country/Region</th>
<th>Year*</th>
<th>Shape</th>
<th>Diameter</th>
<th>Weight</th>
<th>Muzzle Velocity†</th>
<th>Muzzle Kinetic Energy†</th>
<th>Casualties</th>
<th>Cause of Death (Death)</th>
<th>Leading Injuries (Injury)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large, heavy bullet</td>
<td>Northern Ireland</td>
<td>1970–1975</td>
<td>Rubber bullet, 15 cm in length</td>
<td>35 mm</td>
<td>135–140 g</td>
<td>73 m/s (240 fps)</td>
<td>[360–373 J]</td>
<td>1</td>
<td>89</td>
<td>(Death) Severe brain injury associated with depressed fracture of the skull combined with massive shattering of the whole vault of the skull. (Injury) Face/skull fractures (21 cases), ocular injuries (24 cases), severe brain injuries associated with skull fractures (3 cases), lung injuries (7 cases), liver injury, rupture of spleen, perforation of jejunum.</td>
</tr>
<tr>
<td>Shaw</td>
<td>Northern Ireland</td>
<td>1972</td>
<td>Solid rubber with a blunt point, 15 cm in length</td>
<td>38 mm</td>
<td>150 g</td>
<td>116.5 m/s (382 fps)</td>
<td>[1018 J]</td>
<td>0</td>
<td>3</td>
<td>(Injury) Children with pulmonary contusion. Non-penetrating injury, no fractures.</td>
</tr>
<tr>
<td>Small, light bullet</td>
<td>Israel-Palestine</td>
<td>1987–1989</td>
<td>Metal sphere or cylinder covered by a thin (1–2 mm) rubber or plastic coating</td>
<td>—</td>
<td>20 g</td>
<td>—</td>
<td>—</td>
<td>0</td>
<td>69</td>
<td>(Injury) Ocular injuries including 36 ruptured globes.</td>
</tr>
<tr>
<td>Hiss</td>
<td>Israel-Palestine</td>
<td>1987–1993</td>
<td>Improved rubber bullet (IRB): steel, cylindrical or spherical missile coated by a 0.2 cm thick rubber shell</td>
<td>—</td>
<td>15.4 g</td>
<td>100 m/s (328 fps)</td>
<td>77 J</td>
<td>10</td>
<td>0</td>
<td>(Death) Brain injuries (7 cases), cardiopulmonary laceration, spinal shock secondary to neck injury, and blood aspiration secondary to injury of nose. Penetrating injuries were seen in 7 cases. Nine cases were males of 13–25-yr-old. (Injury) Eye injuries include ruptured globe in 38% and orbital fracture in 33%.</td>
</tr>
<tr>
<td>Lavy</td>
<td>Israel-Palestine</td>
<td>2001</td>
<td>IRB</td>
<td>17 mm</td>
<td>15.4 g</td>
<td>100 m/s (328 fps)</td>
<td>[77 J]</td>
<td>0</td>
<td>42</td>
<td>(Injury) Rubber bullet penetrating into the ethmoid sinus.</td>
</tr>
<tr>
<td>Gross</td>
<td>Israel-Palestine</td>
<td>2005</td>
<td>Rubber bullet</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0</td>
<td>1</td>
<td>(Injury) Rubber bullet penetrating into the ethmoid sinus.</td>
</tr>
<tr>
<td>Shell case containing multiple small, light bullets</td>
<td>Israel-Palestine</td>
<td>2000</td>
<td>RCC-95: a cylindrical missile composed of 3 metal cores coated by a 0.2 cm thick hard rubber shell</td>
<td>18 mm each</td>
<td>48 g</td>
<td>130 m/s (427 fps)</td>
<td>46 J/cm²</td>
<td>3</td>
<td>149</td>
<td>(Death) Severe penetrating ocular injury into the sphenoid sinus, severe diffuse brain damage caused by penetrating ocular injury, postoperative aspiration after a knee injury. (Injury) 61% of injuries were blunt injuries and 39% were penetrating. Severe injuries included skull fractures, subarachnoid hemorrhage, pulmonary contusion, hemopneumothorax, cardiac contusion, laceration of spleen, ruptured bowel. RCC-95 bullets were recovered from all patients severely injured.</td>
</tr>
</tbody>
</table>

(Continued)
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<tbody>
<tr>
<td>Voiglio16</td>
<td>France</td>
<td>1998</td>
<td>A 12 gauge cartridge containing 12 rubber bullets</td>
<td>7 mm each</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>1 (Death) Suicide. Perforation of the second and third left intercostal spaces. Rib fractures. Cardiac contusion and pulmonary laceration with hemothorax and hemopericardium</td>
</tr>
<tr>
<td>Kalebi17</td>
<td>Kenya</td>
<td>2000</td>
<td>Shotgun rubber bullet</td>
<td>7.5 mm each</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>0 (Death) Pulmonary laceration due to 7 penetrating injuries to the chest</td>
</tr>
<tr>
<td>Kavoussi4</td>
<td>Texas, USA</td>
<td>2006</td>
<td>Hornet’s nest projectile 12-gauge round. Twenty rubber balls in the shell</td>
<td>7.8 mm each</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0</td>
<td>1 (Injury) Multiple superficially penetrating wounds. Two rubber pellets ruptured one of the testes</td>
</tr>
<tr>
<td>Wahl18 Large, relatively light bullet</td>
<td>Switzerland</td>
<td>2006</td>
<td>Rubber buckshot 9 balls</td>
<td>17 mm each</td>
<td>—</td>
<td>—</td>
<td>200 J</td>
<td>0</td>
<td>1 (Injury) Multiple small round contusions</td>
</tr>
<tr>
<td>Suyama19</td>
<td>Ohio, USA</td>
<td>2001</td>
<td>Sponge foam bullet</td>
<td>40 mm</td>
<td>30 g</td>
<td>99 m/s (325 fps)</td>
<td>[147 J]</td>
<td>0</td>
<td>11 (Injury) Contusions (6 cases), lacerations (on face in 2 cases, head in 2 cases including a case with laceration and post concussive syndrome, leg with Achilles tendon rupture in 1 case)</td>
</tr>
<tr>
<td>Shaw20§</td>
<td>California, USA</td>
<td>2005</td>
<td>Sponge foam bullet</td>
<td>40 mm</td>
<td>30 g</td>
<td>99 m/s (325 fps)</td>
<td>[147 J]</td>
<td>1</td>
<td>0 (Death) Laceration (2.5 inch) of forehead, intracranial trauma</td>
</tr>
<tr>
<td>Kobayashi</td>
<td>Indiana, USA</td>
<td>2006</td>
<td>Sponge foam bullet</td>
<td>40 mm</td>
<td>30 g</td>
<td>99 m/s (325 fps)</td>
<td>[147 J]</td>
<td>0</td>
<td>1 (Injury) Pulmonary contusion</td>
</tr>
<tr>
<td>Wahl18 Swisseland</td>
<td>Switzerland</td>
<td>2006</td>
<td>Rubber ball</td>
<td>44 mm</td>
<td>28 g</td>
<td>[120 m/s] (392 fps)</td>
<td>200 J</td>
<td>0</td>
<td>1 (Injury) Large contusion of the anterior chest, pulmonary contusion, increases of troponin I and creatine kinase</td>
</tr>
</tbody>
</table>

*Year when the injury occurred. If it is unavailable, year of publishing is shown.
†Values in square brackets were determined by calculation.
Including injuries caused by plastic bullets of the same shape and weight.
§Type of bullet and the manufacturer are specified in the report. No values are provided.
stated the officer’s inaccurate placement of the projectile was contributed by several factors including the target’s movement, the projectile’s tendency to rise from the target area when fired, and insufficient training of the officers.

The 40-mm bullet made of sponge foam, which is considered as an improved type of rubber bullet, is not likely to cause penetrating injuries because of the large size and the elastic, round nose. The lacerations and internal organ injuries reported in the literature and the case presented here, however, demonstrate the possibility that the bullets could result in lacerations, severe internal injuries, and death.

**Rubber Bullet Injuries Reported in Literature**

Historical development and modification of rubber bullets have been demonstrated in the literature along with the injuries caused by them. The first attempt to modify a wooden baton for use as a firearm was in the United States, but their first notable use was in Hong Kong during the 1950s and 1960s.8 The first rubber bullet was introduced by British forces in Northern Ireland in 1970.9,13,22 It resembled a baton made of rubber, being 15 cm in length and approximately 140 g in weight. The bullet was highly unstable in flight and lost energy very rapidly because of the trembling movement and high wind resistance.8 Over 55,000 rubber bullets were fired in Northern Ireland between 1970 and 1975.9 The death rate was estimated at one in 16,000 rounds used, and the rates of serious injury and disability were one in 800 and 1900 rounds, respectively.8

Israeli Defense Forces used multiple types of small rubber bullet and plastic bullet during “Intifada (uprising)” between 1987 and 1993.11,12,14,15 They resulted in more than 20 deaths.12 Standard rubber bullets, which were a 2-cm-diameter steel sphere coated thinly in rubber and weighed 14 g, were replaced in 1989 with the improved rubber bullets, which were cylindrical metal bullets coated by rubber of 0.2 cm thickness and were 1.7 cm in diameter and 15.4 g in weight.12,13 Hiss reported 10 fatalities caused by improved rubber bullets, and the rubber coating of the recovered missile was torn and separated from the metal core in many of the cases.12 Since they caused many major injuries or deaths, especially of children or young adults, Israeli Defense Forces issued regulations of their use including a minimum firing distance, not firing at children, and only firing at the legs.13 Use of rubber bullets in Israel was followed by worldwide dissemination of the weapon. A shell containing small rubber pellets, which is similar to a shotgun ammunition, has been widely used,4,16–18 and a case of suicide with this type of ammunition was reported.16

Physicians in the United States have reported treatment of patients with injuries caused by rubber bullets.5,19 Some of them were injured by the type of 40-mm rubber bullets that were used in the case presented in this report.19 Rubber bullets have been continuously improved, and many choices with considerable differences in the shape, weight, material, and muzzle velocity are available at this date.

The majority of injuries caused by rubber bullets are nonpenetrating, blunt force injuries of little medical significance. However, several lethal or serious injuries, some of which are penetrating injuries or large lacerations, have been reported (Table). There appears to be a relation between the feature of injury and the type of bullet. The large, heavy rubber bullets used in Northern Ireland caused multiple casualties with severe blunt force injuries, such as crushing skull or facial fractures or internal organ injuries without penetration. On the contrary, many penetrating injuries as well as many ocular injuries were reported from Israel and other regions where small and relatively light rubber bullets were deployed. Shotgun ammunition-like small rubber pellets in a shell caused similar injuries. Large but comparatively light rubber bullets caused nonpenetrating contusions, occasional lacerations, and rare internal organ injuries. The 40-mm rubber bullets do not appear to cause severe crushing injuries or penetrating injuries. They are probably less likely to cause severe or lethal injuries than the older types of rubber bullet.

Risk factors in occurrence of severe injuries caused by rubber bullets have been suggested, and they include short range, young age of the person hit, and point of impact on the upper body.8,15,16 The severity or features of a rubber bullet injury can depend on many factors of the bullet, such as its mass, size, shape, and velocity on impact,13 as well as those of the target including the thickness of chest or abdominal wall, elasticity of the rib cage, and clothing.

**Problems Regarding Rubber Bullets and Role of Forensic Pathologists**

The circumstances and autopsy findings of the case presented can lead one to contradictory conclusions about the 40-mm rubber bullet: the danger of the weapon producing severe internal injuries that may result in fatality, but yet insufficient effect of the bullet that may not incapacitate the target. This case clearly demonstrated the paradox in developing ideal less-lethal weapons. The effect of less-lethal weapons should be strong enough to incapacitate targets, but they are not supposed to kill them. Rubber bullets were developed and improved to fulfill these demands as if there is a definite line between incapacitating and killing. The bullets need to produce a certain extent of injuries and pain to affect the target, but they are not able to generate injuries of a certain severity in every target. A rubber bullet, however it is modified, would cause major injuries and deaths at a certain probability as long as the weapon is used to incapacitate a person by delivering kinetic energy. It is important for the users to understand the nature of the weapon.

Undoubtedly, less-lethal weapons cause few occurrences of severe injuries and fatalities compared with conventional firearms. It is expected that rubber bullets will continue to be used by many law enforcement agencies, in many situations, and in many countries. Even though the fatalities caused by rubber bullets are rare, forensic pathologists will be involved in the death investigation of the victims. A possible problem will be that interpretation of the rubber bullet injuries is unfamiliar to the majority of forensic pathologists. Some injuries, such as a fatal injury caused by either a rubber bullet shot by a law enforcement personnel or a stone thrown by riot crowds, can be difficult to interpret and also socially problematic with an increased chance for public scrutiny. It is crucial for forensic pathologists to be aware of the variation of rubber bullet injuries and understand the relation between the types of rubber bullets and injuries they produce.

**REFERENCES**


