

Terminal ballistics of the 7.62 mm NATO bullet

Autopsy findings

Peter J. T. Knudsen^{1,2} and Peter Theilade³

¹Institute of Forensic Medicine, University of Aarhus, Finsensgade 15, DK-8000 Århus C, Denmark

²Institute of Forensic Medicine, University of Odense, DK-5000 Odense, Denmark

³Institute of Forensic Medicine, University of Copenhagen, DK-2100 Copenhagen Ø, Denmark

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Summary. The 7.62 mm × 51 military rifle bullet (7.62 mm NATO) as manufactured in Denmark, and in some other countries as well, has been claimed to fragment when fired at ranges encountered in forensic practice. All autopsied cases of death due to this bullet in Denmark since 1975 were investigated by studying autopsy reports and the bullets retrieved by the police. With one exception, all bullets that were found in, or known to have passed through the body, had fragmented. This behaviour is assumed to be due to a lack of strength in the jacket causing it to break at the cannelure when hitting the target at high velocity. The fragments will increase the already sizeable lesions and may leave the body through several separate exit wounds, presenting problems both for the surgeon treating survivors and for the forensic scientists when defining the direction of the shot. The legality of this and similar bullets in view of the Hague Declaration of 1899 may be questioned, and we feel that the bullet should be redesigned. A programme to this end has been initiated by the Danish state owned ammunition factory.

Key words: Gunshot wounds – Wound ballistics – Bullet fragmentation

Zusammenfassung. Das 7,62 mm × 51 Geschoß für Militär-Gewehre, wie es in Dänemark und in einigen anderen Ländern hergestellt wird, soll sich zerlegen, wenn es aus Entfernungen abgefeuert wird, welche in der forensischen Praxis üblich sind. Alle autopsierten Todesfälle, die seit 1975 durch dieses Geschoß verursacht wurden, wurden durch eine Untersuchung der Autopsie-Berichte und der von der Polizei zurück bekommenen Geschosse überprüft. Die Geschosse, welche in den Leichen gefunden wurden bzw. welche den Körper passiert hatten, waren mit einer Ausnahme fragmentiert. Dieses ist vermutlich darauf zurückzuführen, daß es einen Mangel an Stärke im Geschoßmantel gibt, wodurch dieser bricht,

wenn das Geschoß mit hoher Geschwindigkeit auf das Ziel trifft. Die Fragmente haben eine Vergrößerung der bereits beträchtlichen Läsion zur Folge und können den Körper durch mehrere separate Ausgangswunden verlassen. Dies verursacht Probleme sowohl für den Chirurgen, der den Verletzten behandeln soll, als auch für den Rechtsmediziner, der die Schußrichtung feststellen soll. Auf dem Hintergrund der Haager Deklaration von 1899 müßte die Legalität dieser und ähnlicher Geschosse in Frage gestellt werden, und wir vertreten die Auffassung, daß dieses Geschoß umkonstruiert werden muß. Ein Programm mit dieser Zielsetzung wurde bei der dänischen staatlichen Munitionsfabrik begonnen.

Schlüsselwörter: Schußverletzungen – Wundballistik – Geschoßfragmentation

Introduction

The effect of military rifle ammunition has been the centre of controversy for many years. Ever since the end of the nineteenth century when the full metal jacketed (FMJ) bullet was invented, the trend has been towards faster bullets and smaller calibres, a trend that has culminated in the present 5.56 mm calibre in NATO and 5.45 mm in the ex-Warsaw Pact countries. The 7.62 mm × 51 (7.62 mm NATO) cartridge has been overshadowed by its more famous small calibre successors, but there have been reports in the literature (Fackler 1989) that some makes of this bullet – by many thought to be less harmful than the small calibre bullets – are more efficient than originally assumed. This may be due to a difference in the design between the US manufactured bullets and those made in Europe, e.g. in Germany and Denmark. The US bullet – the M80 – has a jacket thickness of 0.8 mm, while at least some European bullets have a jacket thickness of 0.55 mm. In order to correlate the observations made in experiments with tissue or tissue simulants

with real life observations, it was decided to investigate cases of fatal injuries due to the 7.62 mm NATO bullet of European manufacture.

Material and methods

The rifle and the bullet. The 7.62 mm NATO bullet was introduced in Denmark for use in rifles in 1975, when the Armed Forces decided to replace the previous standard infantry rifle, the 7.62 mm Garand of World War II vintage, with the new M75 standard infantry rifle, the Heckler & Koch G3. The rifle, which was introduced in 1975, hence the designation, is a reasonably modern type, capable of single and fully automatic firing.

The 7.62 mm NATO bullet is conventionally constructed, with a lead core encased in a jacket made of gilding metal or gilding metal plated steel. The muzzle velocity of the rifle/bullet combination is approx 780 m/sec. The jacket material and thickness may vary from manufacturer to manufacturer. The Danish "Ammunitionsarsenalet" (AMA) bullet has a jacket made of gilding metal plated steel with a thickness of 0.55 mm, the jacket of the US M80 is made of gilding metal or gilding metal plated steel and has a thickness of 0.80 mm, the jacket of the Hirtenberger (Austria) bullet is made of gilding metal plated steel with a thickness of 0.55–0.60 mm and the Raufoss (Norway) bullet has a jacket made of gilding metal with a thickness of 0.75 mm (Manufacturers' information: AMA, Hirtenberger and Raufoss and own measurements: M80). The cartridge was initially purchased from Hirtenberger but is now manufactured domestically for use in the Danish Armed Forces by the state owned "Ammunitionsarsenalet".

Case investigation. All the known cases of fatal lesions from the bullet in question were taken from the files of the 3 Institutes of Forensic Medicine in Denmark and the files of the National Forensic Laboratory (NFL) in Copenhagen. When the cases had been identified the police records were obtained, with the permission of the Ministry of Justice, in order to study the details of the incidents and in some cases to obtain supplementary photographic evidence which had not been forwarded to the NFL, as the cases had been handled locally. Such cases were typically those where suicide or the accidental firing of the weapon was obvious.

For the investigation, only cases with a full autopsy were included. This selection meant that 18 autopsied cases since 1975, when the weapon was introduced in Denmark, were available for the study. In each case the age and sex of the deceased, the cause and manner of death, the range and particulars of the entry and exit wounds and of the lesions, and finally particulars of retained bullets or fragments of bullets were recorded. As much information as possible was collected from the police files and from the examinations performed at the NFL about the weapons and bullets used, the year of manufacture, the places where the bullets were found and, in detail, the condition (size, shape, weight etc.) of the bullets or fragments of bullets.

In all cases where bullets, fragments of bullets or photographic material were available, they are reproduced here, with the permission of the NFL. Only in 2 cases had the evidence been destroyed, one (no. 9) being a case of suicide with no special interest to the police at that time, the other one (no. 10) a case, where the fragments were so minute that they had been deemed to be useless for forensic use.

While only cases with proper documentation of lesions and projectiles can contribute properly to the solution of the problem, all cases of death after the use of the G3 rifle in Denmark have been included and are listed below. All the bullets were manufactured by AMA unless otherwise specified.

Autopsy findings

Case 1. An 18-year-old man was found shot at close range. An entry wound was found in the thorax and the path of the bullet

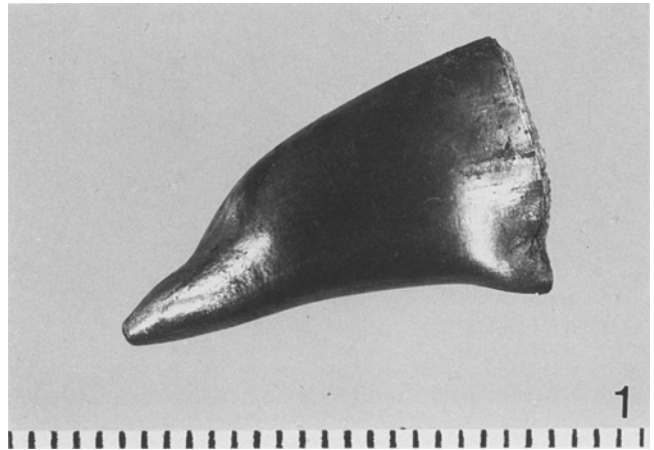


Fig. 1. Case 4. Part of the tip of the bullet found just below the skin at the exit wound

could be followed through the left lung. Two exit wounds were found in the back. No fragments of the bullet were found.

Case 2. A 22-year-old man shot himself by firing a rifle against his forehead. The whole of the cranial vault was blown away. No fragments of the bullet were found.

Case 3. A 16-year-old boy shot himself by placing the muzzle of the rifle against his chest where an entry wound was found. An exit wound was found below the shoulder blade. Two fragments of the jacket of the bullet or bullets were found at the scene.

Case 4. A 15-year-old man was shot when the rifle accidentally discharged at close range. An entry wound was found on the chin. The path of the bullet could be followed through the mandible, the hyoid bone, the thyroid, the cervical spine, left clavicle, the shoulder blade to an exit wound on the left shoulder. A fragment of the bullet consisting of the foremost tip was found just below the skin at the exit wound (Fig. 1). No fragments were found at the scene. In this case Hirtenberger ammunition was used.

Case 5. A 30-year-old man shot himself in a depot room. An entry wound was found just above the left nipple. The path of the bullet could be followed through the left lung to an exit wound in the back. No fragments of the bullet were found in the body. The lead core of the bullet was found at the scene.

Case 6. A 35-year-old man was shot 5 times at close range. Two entry wounds were found just below the navel, 2 below the right armpit, and one above the right inguinal ligament. Exit wounds were found in the back, under the left armpit and on the left shoulder but none corresponding to the entry wound above the inguinal ligament could be established. No fragments of the bullets were found in the body. The 3 fragments of bullets found at the scene were a flattened bullet in the undershirt near the left shoulder, the tip of a bullet lying loose in the undershirt (Fig. 2a) and the third one was the tip of a bullet found in a pillow (Fig. 2b).

Case 7. A 29-year-old man was shot twice at close range. At entry wound was found in the right temple. The path of the bullet could be followed through the skull and the mandible, exiting on the right side of the neck, and passing into the right shoulder through a secondary entry wound. Another entry wound was found on the front of the right shoulder leading to the shattered proximal extremity of the humerus. A corresponding exit wound was found in the back. Minute fragments of the bullets were found by X-ray in the skull and the shoulder. Part of the jacket and the lead core of the tip of 1 or 2 bullets were found at the scene.

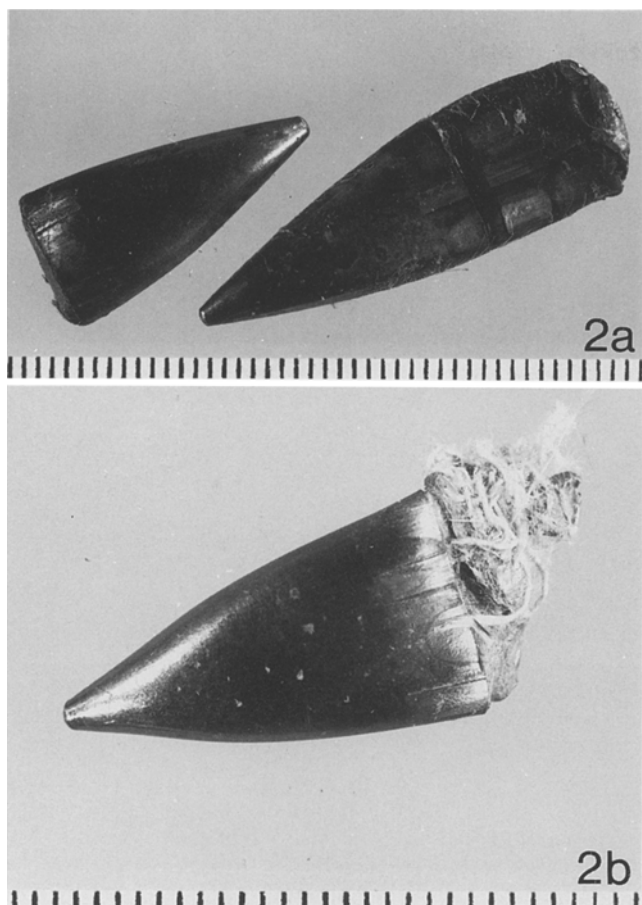


Fig. 2a, b. Case 6. **a** A flattened bullet and the tip of a bullet found in the victim's clothes. **b** The tip of a bullet found in a pillow



Fig. 3a, b. Case 8. **a** Part of the jacket found in the body of the deceased. **b** A flattened, but whole bullet and parts of the jackets and lead cores of up to 4 other bullets found at the scene

Case 8. A 31-year-old man was shot by accident. An entry wound was found in the right temporal region with an exit wound behind the left ear. A fragment found in the deceased was part of the jacket (Fig. 3a), while 5 fragments found at the scene were one flattened but whole bullet and parts of the jackets and lead cores of up to 4 other bullets (Fig. 3b).

Case 9. A 26-year-old man shot himself by placing the rifle against his neck. An entry wound was found on the right side of the neck, just below the mandible and the path of the bullet could be followed upward through the brain. The exit wound covered a large part of the parietal region. No fragments of the bullet were found.

Case 10. A 20-year-old man was shot 2 or 3 times at close range, a total of 8 shots were fired. Three lesions were found. One bullet had perforated the right thigh, another, possibly the same bullet, had perforated the left hand, while the third and lethal bullet penetrated the right side of the chin and passed through the mouth, pharynx and cervical spine to a large exit wound on the left side of the back of the neck. Four minute metallic fragments found in the body were not preserved, while the 4 fragments found at the scene consisted of both large and small parts of up to 4 bullets. These bullets were of Hirtenberger manufacture.

Case 11. A 63-year-old man was shot 3 times at a range of 27 metres. An entry wound was found on the left side of the thorax, another one in the right side of the thorax and a final one in the left upper arm. The path of the first bullet could be followed through both lungs and through the right clavicle to an irregular exit wound. A fragment of a bullet was found in the right lung. The

path of the second bullet passed through the liver, where a small particle of the bullet was found, to an exit wound on the back. The third bullet seemed to have penetrated the upper arm, exiting on the inside with a small exit wound, and another large exit wound in the left armpit. Four bullet fragments were found in body, from shot no. 1 and 2, and fragments of bullet no. 3 could be located by X-ray in the region of the head of the humerus, which was shattered. Three fragments were found at the scene. The fragments found or radiographically demonstrated in the body corresponded to 3 bullets, those found on the scene to 1–3 bullets. The fragments in the body consisted of 2 fragments of bullet jacket and 2 pieces of lead core (Fig. 4a), while the fragments at the scene were the base of a bullet and 2 pieces of lead core (Fig. 4b).

Case 12. A 29-year-old man shot himself in the left temple at a range of a few centimetres. The path of the bullet could be followed through the brain to an exit wound in the right temple. No fragments of the bullet were found.

Case 13. A 14-year-old man was shot accidentally at close range. An entry wound was found in the thorax. The path of the bullet could be followed through the thoracic wall, through the heart and the upper part of the aorta and exiting the thorax through the 8th. thoracic vertebra. No fragments of the bullet were found in the body. Five fragments were found at the scene, being parts of the jacket and tracer insert of a tracer bullet.

Case 14. A 45-year-old man shot himself by placing the muzzle of the rifle on the palate where an entry wound was found. The path

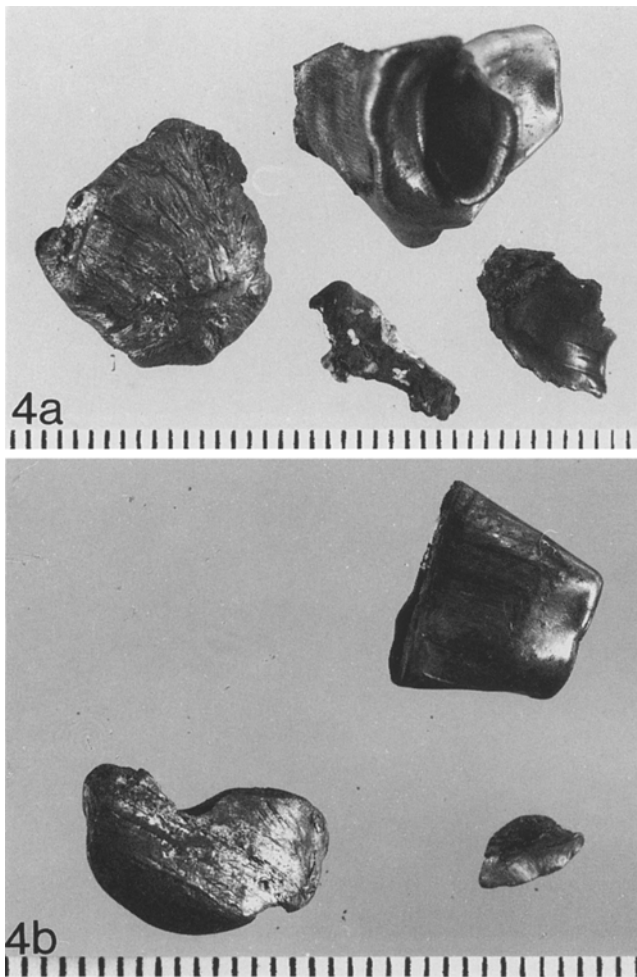


Fig. 4a, b. Case 11. **a** Two fragments of bullet jacket and two pieces of lead core found in the body. **b** The base of a bullet and two pieces of lead core found at the scene

of the bullet could be followed through the brain. The skull had shattered completely. No fragments of the bullet were found.

Case 15. A 43-year-old man was shot several times at close range. Entry wounds from two bullets were found. The path of a bullet entering the abdomen could be followed through the intestines, the liver and the right kidney. A second bullet had passed through the arm and entered the thorax, breaking the ribs and causing a severe lesion of the left lung. No fragments were found in the body, but the deformed tips of 2 or 3 bullets were found at the scene.

Case 16. A 41-year-old woman was shot at close range, (less than 3 metres). Wounds from 5 bullets could be distinguished. One bullet fired at very close range hit the right side of the neck, making a small entry wound, passing through the base of the skull. A bullet entered the lower part of the front of the neck, went through left lung and left the thorax below the shoulder joint. Another bullet perforated the arm just above the elbow. A bullet entered the right thigh, passed through the organs of the pelvis and ended in the right flank, where part of a projectile was recovered under a very small wound. The final bullet entered the left thigh, hit the pelvis and bladder and left the body in the left flank through at least two exit wounds. A fragment of the bullet was found here. The fragments in the body consisted of the deformed lower part of the jacket with some lead (Fig. 5a), while the 11 fragments found at the scene were deformed tips and pieces of lead core of the bullets (Fig. 5b and c).

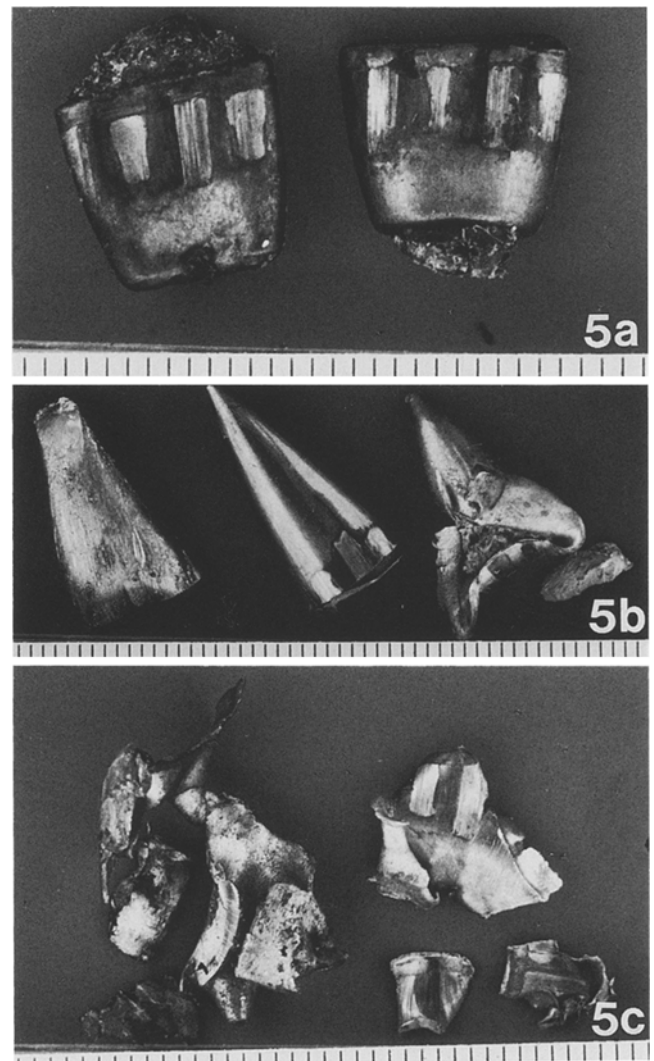


Fig. 5a-c. Case 16. **a** The deformed lower part of the jacket with some extruded lead found in the body. **b** and **c** 11 deformed tips and pieces of lead core of the bullets found at the scene

Case 17. A 20-year-old man was accidentally shot in the head. An entry wound near the left margin of the left eyebrow was found. The path of the bullet could be followed through the dilacerated brain to the back of the head, which was missing. The tip, the base and the lead core of the bullet, divided through the cannellure were found at the scene.

Case 18. A 31-year-old man shot himself by putting the muzzle of the rifle against the palate where the entry wound was found. The path of the bullet could be followed through the brain to an exit wound in the parietal region. No fragments of the bullet were found in the body. The base of a bullet with extrusion of lead was found at the scene. In this case a Norwegian license-built version of the G3 was used, the AG3, with ammunition by the Norwegian firm Raufoss.

The autopsy findings of the above mentioned cases are summarized in Tables 1 and 2.

Discussion

The 7.62 mm \times 51 bullet has been NATO standard for many years, and it has been regarded as the archetypal

Table 1. Particulars about the victim and the circumstances of the case

Case	Sex	Age	Cause of death	Manner of Death	Range in metres
1	M	18	Lesion of thoracic organs	Accident/suicide	0–50 cm
2	M	22	Lesion of brain	Suicide	Contact wound
3	M	16	Lesion of thoracic organs	Accident/suicide	Contact wound
4	M	15	Lesion of cervical medulla	Accident	2 metres
5	M	30	Lesion of thoracic organs	Suicide	Contact wound
6	M	35	Lesion of thorax and abdomen	Homicide	3–5 metres
7	M	29	Lesion of head	Homicide	3–5 metres
8	M	31	Lesion of head	Accident/homicide	3–5 metres
9	M	26	Lesion of brain	Suicide	Contact wound
10	M	20	Lesion of cervical medulla	Homicide	3–5 metres
11	M	63	Lesions of lung and liver	Homicide	27 metres
12	M	29	Lesion of brain	Suicide	Contact wound
13	M	14	Lesion of heart	Accident	1–2 metres
14	M	45	Lesion of brain	Suicide	Contact wound
15	M	43	Lesion of liver	Homicide	3 metres
16	F	41	Lesion of head and neck	Homicide	0.5–3 metres
17	M	20	Lesion of brain	Accident	1 metre
18	M	31	Lesion of brain	Suicide	Contact wound

Table 2. Details about the findings at autopsy

Case	Entry wounds		Exit wounds		Bone contact	Bullets retrieved in body		Bullets retrieved at scene	
	<i>n</i>	Location	<i>n</i>	Location		Fragments	Fragments	Intact	
1	1	Thorax front	2	Thorax back	–	–	–	–	
2	1	Forehead	1	Skull	+	–	–	–	
3	1	Thorax front	1	Thorax back	–	–	2	–	
4	1	Chin	1	Shoulder	+	1	–	–	
5	1	Thorax front	1	Shoulder	+	–	1	–	
6	5	Thorax, front, axilla	4	Shoulder, back, axilla	+	–	2 ^a	1 ^a	
7	2/3 reentry	Right temple Right shoulder	2	Neck Thorax back	+	Several	2	–	
8	1	Right temple	1	Below left ear	+	1	4	1	
9	1	Neck	1	Parietal region	+	–	–	–	
10	2/3 reentry	Right thigh and left hand Chin	2/3	Right thigh and left hand Back of neck	–	4	4	–	
11	3	Right thorax front Left thorax back Left arm	4	Back Lower back Left arm (2)	+	4 ^b	3	–	
12	1	Left temple	1	Right temple	+	–	–	–	
13	1	Thorax front	1	Thorax back	+	–	5	–	
14	1	Palate	1	Skull	+	–	–	–	
15	3	Abdomen Arm Axilla	3	Back Arm Back	–	–	3	–	
16	5	Right side of the neck Front of the neck Right elbow Right thigh Left thigh	6	Left side of head Back of left shoulder Right arm Right flank Left flank	+	2	11	–	
17	1	Left eyebrow	1	Back of head	+	–	3	–	
18	1	Palate	1	Skull	+	–	1	–	

^a Two fragments and one intact bullet found in clothes^b Plus many small fragments found on X-ray

military rifle bullet, which yaws through 180° in the target, but remains intact unless hitting bone (Cooper and Ryan 1990; diMaio 1985; Fackler 1988; Fackler and Malinowski 1985). It has been demonstrated, however, that the European version of this bullet has a tendency to fragment when hitting tissue simulants such as ordnance gelatin (Fackler 1989). The research in this field has been done in Europe (Sweden and Yugoslavia) and in the US. By carefully reading the European papers it can be seen that those researchers have noted that the Swedish version of the NATO bullet, the 7.62 mm sk ptr 10 prj, has a similar tendency to fragment (Berlin et al. 1988; Nordstrand et al. 1979), and the Yugoslavian researchers have noted fragmentation of an unidentified 7.62 mm NATO bullet (Albrecht et al. 1979). The US version (M80) does not fragment at comparable velocities (Ragsdale and Sohn 1988), and the difference is ascribed to the fact that the jacket of the M80 is 0.8 mm thick, while that of the European bullet is only 0.55 mm (Fackler 1989). An explanation for the lack of fragmentation noted in other papers may be that many experiments have been performed at ranges of 100 m (Berlin 1977; Berlin et al. 1976, 1977, 1988; Nordstrand et al. 1979), which may well be near the lower limit of velocity of the break-up of the bullet. The previously mentioned Yugoslavian study by Albrecht et al. (1979) revealed fragmentation in most cases when shooting from 50 m, a phenomenon which has also been described by Cooper and Ryan (1990).

Tissue simulants provide reproducible measurements, but wherever possible we should look at real life situations and try to correlate the experiments with the experience of surgeons and forensic pathologists. Therefore it was thought to be of interest to study actual fatal cases with this bullet.

When considering the cases which form the basis for this investigation, it is at once apparent that the rifle has been fired at very close ranges, certainly much shorter than what can be expected in a military setting. The short range means that the bullet is travelling at or close to muzzle velocity. It can also be assumed that the bullet has not yet stabilized in flight and has therefore hit the victim at an angle (Berlin 1977; Berlin et al. 1976; Cooper and Ryan 1990; Hopkinson and Marshall 1967). Although this phenomenon has been much exaggerated in the past (Fackler 1988), it will contribute to the early yawing of the bullet after the target (Sellier and Kneubuehl 1992). The appearance of entry wounds varied, some were large and irregular, others were small and circular.

The exit wounds are of special interest, not so much by their appearance as by their number. Two or more exit wounds from one bullet are encountered regularly if a large enough number of gunshot cases are reviewed, and indicate that the bullet has fragmented or that it has hit bone, creating secondary missiles capable of penetrating skin. In cases 4, 7, 8, 10, 11 and 16 fragments of bullets have been recovered at autopsy and when one or more exit wounds are found, the bullet has obviously fragmented in the body and the exit wounds have been caused by overpenetrating fragments. This issue may be clouded when, as in cases 8, 10, 11 and 16, there are

multiple shots, but in cases 1 and 16 there is reason to believe that a single bullet has fragmented and caused the 2 exit wounds.

The possibility of 2 exit wounds from one bullet has legal implications: supposing that a line connecting the entry and one of the exit wounds means that the victim could not have shot himself, whereas another line connecting the entry wound and the other exit wound makes it possible. Suicide or homicide? The forensic pathologist must realize that it may not be the line connecting entry and exit wounds that defines the trajectory of the bullet, rather it is the direction of the first 5–10 cm of the wound channel – corresponding to the “neck” or “narrow channel” as seen in simulants – that should be used to define the direction (Sellier and Kneubuehl 1992).

Similarly, surgeons treating wounds from FMJ high velocity military rifle bullets must not fall into the trap of suspecting only injuries along a straight line connecting entry and exit wounds. Surgeons with recent war experience tell us that anything can be expected from that kind of weapon (Cooper and Ryan 1990; Fackler 1989), indeed a deviation in the latter part of the trajectory is common (Sellier and Kneubuehl 1992).

It may well be argued that any bullet may fragment when hitting bone, and that hitting bone is very common in real life. Indeed, lethal hits to the body will in most cases involve bone contact, as will of course all lethal hits to the skull (Table 2). Nonetheless, in the case of the 7.62 mm NATO all but one of the bullets hitting the victim fragmented (Fig. 2), and they fragmented in a very consistent way, flattening and breaking at the cannelure producing strikingly similar fragments (Figs. 1–5). It is natural to suggest that the reason must be something more than the chance of hitting bone and FMJ bullets are known to be able to perforate a femur without noticeable marks on the bullet (Ragsdale and Josselson 1988). This observation is made for relatively slow bullets, but makes it less likely that all fragmentation should be due to bone contact. The study by Albrecht et al. (1979), excluding bone hits and shooting at 50 m also found fragmentation. Unfortunately, they do not identify the country of origin or the manufacturer of the bullets used.

The practical consequences of these observations are several: firstly, fragmentation can be expected, and 2 or more exit wounds are not uncommon with these bullets. Secondly, the path of the bullet may not be linear – since there may be 2 or more fragments, it is likely that they will take different paths – and lesions should not only be expected in a line connecting the entry and exit wounds, but also at a distance of perhaps 10–15 cm from this. Furthermore, if there are 2 or more exit wounds, which should be chosen to determine the direction of the shot? In none of the cases mentioned above was this a problem, but the pathologist should be prepared to explain the matter in court.

Finally, the legal aspect. Is the 7.62 mm NATO bullet in its European version legal when viewed in the light of the Hague Declaration of 1899? (Knudsen 1990; Ragsdale 1984; Sellier and Kneubuehl 1992). This question has been discussed at length in the case of the 5.56 mm

M16 bullet. The authors are not legally trained, but it would seem reasonable to assume that a bullet which consistently deforms and breaks into 2 or more fragments when hitting a person at ranges below 100 m contravenes the statement "...easily flatten..." (Cooper and Ryan 1990; Coupland et al. 1992). There is no reason to believe that the manufacturers have wilfully made their bullet so that it will fragment, witness the US version, which is identical except for the 0.3 mm thicker jacket, but very little basic wound ballistics seems to have been done when the design was finalized. By itself a "NATO standard" which does not take into consideration the thickness or strength of the jacket seems questionable. The fragmentation is of the utmost importance since its contribution to the destructive effect of modern military rifles has been stressed repeatedly (Berlin 1977; Berlin et al. 1976, 1977; Cooper and Ryan 1990; Coupland et al. 1992; Fackler et al. 1984).

There are several possible solutions to the problem: change the thickness of the jacket from 0.55 mm to 0.8 mm, replace the material of the jacket with something more ductile or as the third alternative, strengthen the part of the bullet which breaks, the cannelure, where the case is attached to the bullet (Berlin et al. 1988).

As a result of this investigation, and on the basis of the literature reviewed, the AMA has decided to conduct a series of experiments to compare the performance of the M80 with that of their own product. If the assumptions made by the authors and other writers are proven correct, the AMA will redesign their bullet along the lines recommended here, and one of the authors (PJTK) has been invited to participate in the investigation.

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