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CASE REPORT

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A New Type of Shotgun Ammunition Produces Unique Wound Characteristics

ABSTRACT: The Tucson Police Department, Tucson, AZ, has begun using the Polyshok Impact Reactive Projectile (IRP), a new type of shotgun ammunition that includes a lead bead core that travels within single, plastic-encased projectile. On impact, the core is released to distribute over a small area, thereby disintegrating on impact to reduce the likelihood of exit or collateral damage on missed shots. After a brief review of shotgun slug ballistics and wound characteristics and a discussion of the mechanism of the Polyshok IRP, we report the first death in the United States from this ammunition. Findings included a single entrance wound with plastic ammunition components and small lead particles recovered from the body, the combination of which normally would suggest a close-range shooting with birdshot. However, the characteristics of this ammunition create different patterns than are found with slugs or shot, so that a medical examiner unfamiliar with the Polyshok IRP could draw inaccurate conclusions about ammunition and range of fire. Because the single projectile fired from this ammunition is composed of both plastic and lead, plastic components are likely to be found within the wound at any range of fire, unlike traditional shot or slug ammunition. Also, the small size of lead particles found spread through the wound cavity would ordinarily suggest a small-size shot, whereas the external appearance of the wound (a single entrance with no dispersion of shot) and the pattern of tissue destruction are more consistent with the patterns of injury associated with shotgun slugs.

KEYWORDS: forensic science, forensic pathology, ballistics, shotgun, slug, gunshot wound

Law enforcement and military agencies worldwide use specialized types of shotgun ammunition, ranging from less than lethal ammunition such as tear gas, beanbags, rubber bullets, or plastic shot, to lethal rounds, such as buckshot or solid slugs (1). Both intentional and unintentional wounds from specialized ammunition, as well as unusual or unique ammunition used by nonlaw enforcement personnel, are often described in the literature to illustrate various injuries that surgeons or medical examiners may encounter (2–7).

Shotgun slugs of various types are generally used for large game hunting or for law enforcement applications (1,8). Because slugs are used less frequently, slug injuries are less common than buckshot or birdshot injuries (3,4,8–10). DiMaio (11) writes that shotgun slug entrances are usually circular in shape, with their diameter approximating that of the slug. Wound edges are abraded as with other solid projectiles.

Like high-velocity rifle projectiles, shotgun wounds from any ammunition type, especially at close range, are associated with massive tissue destruction (3,8,10,12–14), and slug wounds may be especially destructive at contact range, as the large defect from the projectile permits entry of gases sufficient to shatter skulls (4,15). Unlike high-velocity rifle rounds, the degree of destruction in shotgun wounds is due not to the velocity component of the kinetic energy equation (kinetic energy = 1/2 mass $\times$ velocity^2), but to the considerably larger mass of a pellet cluster or slug (12). Shot relies on a bolus blast effect as well as surface area-to-volume ratio (factored into the drag coefficient) to maintain velocity; thus, kinetic energy at range decreases with shot size (14). Slugs will retain more accuracy and range than shot, giving tactical flexibility for law enforcement (1).

Their soft lead composition allows easy deformation (1), so, in the body, slugs may flatten (depending on type), and may remain whole or break into large pieces (4,9,13,15,16). Although uncommon, the "lead snowstorm" effect typical for partially jacketed high-velocity rifle projectiles may be seen in some cases (17). Whether they remain in the body or exit, extensive soft tissue damage is associated with slug injuries. The Tucson Police Department, Tucson, Arizona, has begun using in the field a new type of shotgun ammunition similar to a slug, the Polyshok Impact Reactive Projectile (IRP), manufactured by Polyshok Inc. (Allen A, Tucson Police Department, personal communication, 2005). The Polyshok ammunition is a 12-gauge, $2\frac{3}{4}$ in. shell containing a low-density polymer body surrounding a mesh spherical lead bead core, capped in turn by a high-density polymer actuator (see Figs. 1 and 2) (18). The lead beads are less than 1 mm in diameter. Upon firing, the body, core, and actuator leave the barrel as a unit, thus making this projectile most analogous to a slug, without the cone-shaped spread seen with shot. On impact, the actuator initiates separation of itself and the projectile body from the lead bead core. The actuator then disperses the lead beads at a 90° angle to the target, creating a projectile with a broad face: "Over the next two to three milliseconds, the actuator expands the core up to three inches in diameter, and while comprised of up to 14,000 individual particles, is still operating as though it were a solid object" (Fig. 3) (18). With such a wide surface area exposed, kinetic en-

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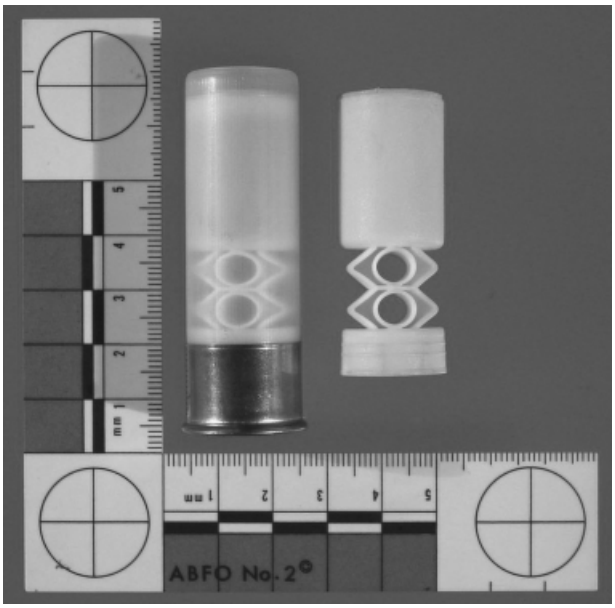

FIG. 1—*Left—shotgun cartridge containing projectile. Right—projectile.*

ergy is rapidly transferred to the target; this quick energy dump results in damage at the impact site, but no solid projectile capable of traveling through the target, hence reducing the likelihood of collateral damage. This is in sharp contrast to the ability of shotgun slugs to exit (10). While shotgun slugs are cited for their "high penetration ability" (1), the rapid energy dump of the Polyshok IRP upon impact with any solid object strongly reduces the likelihood of unintentional damage on missed shots, thereby making this ammunition desirable for law enforcement use. According to Polyshok Inc. (18), this ammunition causes a permanent wound cavity up to 8 in. deep and 5 in. in diameter for both bare and heavy denim-clad 10% ordinance gelatin.

Body Armor, Standard Slugs, and Polyshok IRP

Roberts and Bullian (19) found that solid shotgun slugs tended to penetrate standard United States Military Personal Armor System, Ground Troops Fragmentation Vests, which are designed for protection from artillery and bomb fragments. Such penetration of armor is highly unlikely with the Polyshok IRP, due to its expansion upon impact and its composition of lead beads, rather than a solid projectile. Liden et al. (20) demonstrated that with no. 1 shot with a 12-gauge shotgun against 12-ply Kevlar without padding underneath at a range of 3 m did not penetrate, but caused a 4×6 cm oval skin and subcutaneous tissue injury with surrounding ischemia, pleural lacerations, and lung hemorrhages in pigs. Standard shotgun slugs penetrate NIJ Threat Level II vests, but testing by Polyshock Inc. (18) suggests that against body armor, the Polyshok IRP would have the same blunt force effect as standard slugs already in use by law enforcement.

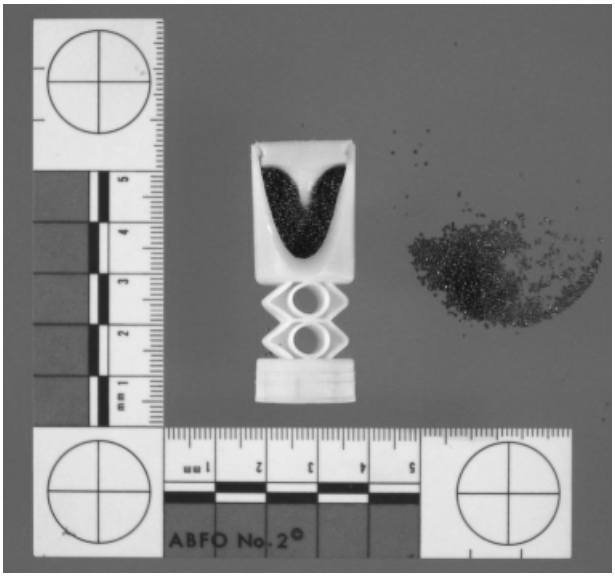

FIG. 2—*Left—cutaway projectile showing actuator and surrounding lead beads. Right—representative lead beads as would be found from wound.*

Case Report

A 40-year-old male was shot at a range of approximately 25 ft with the Polyshok IRP ammunition after he presented a gun to law enforcement and did not drop it despite repeated requests to drop the gun. He was pronounced dead at the scene. At autopsy, on the right upper chest of the decedent's knit polo shirt was a ragged oval defect measuring $1/2 \times 5/8$ in. Just lateral to this defect was a $1/2 \times 1/4$ in. defect. Soot and unburned gunpowder particles were not visible around either of these defects on the shirt. An entrance wound measuring $1 \times 3/4$ in. was on the right chest superiomedial of the right nipple. Soot, unburned gunpowder particles, and stippling were not visible on the skin surrounding this entrance wound. The wound was centered within a $2\frac{1}{4} \times 1\frac{1}{4}$ in. purple contusion (Fig. 4). A postmortem radiograph demonstrated innumerable minute opacities dispersed throughout the right chest cavity, pericardial sac, and right upper quadrant of the abdomen (Fig. 5). The wound path perforated the musculature of the right chest, anterior right ribs 4–6, the right lung, pericardium, and right atrium. Graze defects were present on the diaphragm and liver. The right chest cavity had 1 L of blood and the pericardial sac had 150 mL of blood. Recovered from the pericardial sac were the plastic body and actuator (Fig. 6). Numerous gray metallic particles less than 1 mm in diameter were recovered from the right lung, heart, diaphragm, and liver as well as in the hemothorax and hemopericardium. There were no projectiles found in the left chest cavity and none penetrated the posterior wall of the right

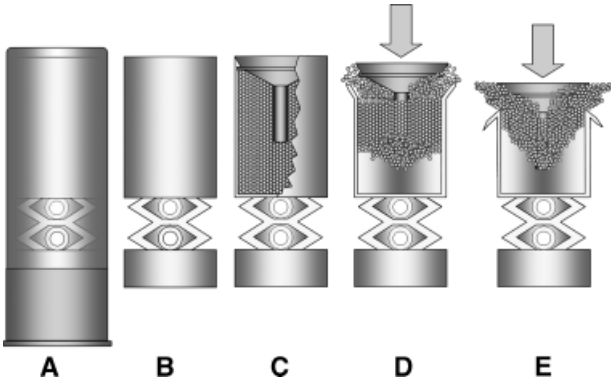

FIG. 3—*Schematic diagrams of the Polyshok IRP (A): Projectile within 12-gauge casing. (B): Projectile as it leaves the barrel. (C): Cutaway diagram of projectile to show actuator situated over lead beads. (D): Cutaway diagram of projectile upon impact, actuator is depressed (arrow) and begins to spread lead beads as projectile body begins to peel away. (E): Actuator continues to spread beads into 3-in. mass (recreated from Polyshok Inc., personal communication, November 2005).*

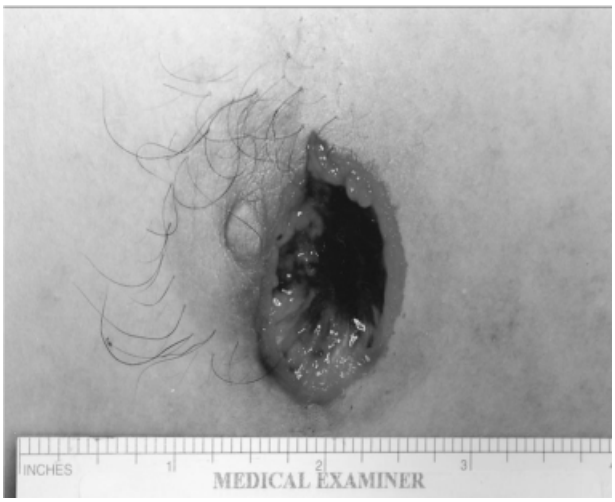

FIG. 4—*Entrance shotgun wound measuring 1 × 3/4 in. was on the right chest superiomedial of the right nipple. Note absence of soot, unburned gunpowder particles, and stippling.*

chest or the vertebral column. There was no evidence of any natural disease. Postmortem toxicology detected only ethanol in the blood and vitreous, 0.24% and 0.29%, respectively.

Discussion

The entrance wound in this case is characteristic of a wound caused by either a solid projectile such as a slug or by a cluster of shot that has not spread sufficiently to create scalloping or individual pellet wounds. The internal findings of tissue disruption are characteristic of the large kinetic energy transfer typical for shotgun wounds. However, the findings of small lead particles are most consistent with very fine shot. DiMaio (11) states that shot cups or wadding are typically not found in shotgun wounds at ranges beyond 6 ft; in this case, the plastic ammunition body and actuator were recovered from the pericardial sac, although the range of fire was approximately 25 ft. Ordinarily, the findings of small shot and plastic ammunition components with a single entrance wound would suggest a shorter range. However, because the projectile of the Polyshok IRP travels most like a slug, inferences about range are considerably different. Thus, a lack of familiarity with this type of ammunition could fool an examiner.

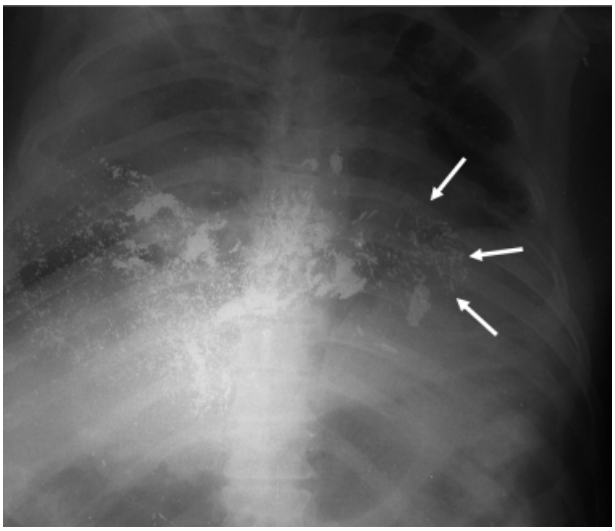

FIG. 5—*Postmortem radiograph with dispersed lead beads throughout right chest cavity, pericardial sac, and right upper quadrant of the abdomen. Arrows denote pericardial sac.*

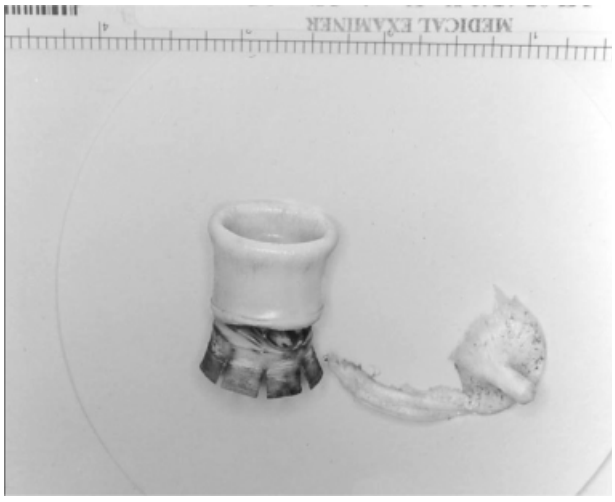

FIG. 6—*Plastic body and actuator recovered from the pericardial sac.*

Acknowledgments

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