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Research Article

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The Efficacy and Wounding Potential of 9 mm Projectiles Tested in the Near Human Porcine Model

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Abstract

Objective: The tested 9 mm projectiles will not have enough momentum and penetration to reach the vital organs inside the thoracic cavity after contacting solid cylindrical bone.

Materials and Methods: Four different 9 mm projectiles were evaluated. Three of them were the popular FBI and law enforcement Jacketed Hollow Points (JHP) and the fourth a solid copper fluted projectile. Rounds were fired through a standard handheld pistol into a combined shoulder and chest near human porcine model.

Results: Two of the JHP projectiles and the solid copper projectile penetrated through the shoulder into the chest cavity. One JHP projectile did not enter the chest cavity at all. All JHP projectiles fragmented and did not expand intact after penetrating through bone. The solid copper projectile remained virtually intact after penetrating through bone. It also penetrated through additional layers.

Conclusion: Not all JHP projectiles will be lethal in the near human anatomical model after penetrating solid bone. All JHP (Jacketed Hollow Points) fragmented and did not expand intact as in ballistic gel testing. The solid copper projectile had the deepest penetration and retained its composition intact.

Keywords: 9 mm Rounds; Ballistic Testing; Near Human Porcine Model; Wounding Capacity; Projectile Fragmentation; Solid Fluted Copper Projectile

Introduction

In 1986 in Miami, a notorious shootout took place on April 11th between two bank robbers and the Federal Bureau of Investigation (FBI). Two special agents, despite wounding both criminals, were killed by the criminals. The FBI casualties were higher than any similar contact in FBI history. Despite being wounded, the bank robbers fired and mortally wounded two FBI agents [1]. A thorough investigation of the incident followed and partial blame for the serious injuries and deaths was attributed to deficient stopping(penetrating) power of the FBI's service handguns. The handgun projectiles did not have enough momentum to reach the vital organs to be lethal. The problem is the diversity of tissue compactness, density and hardness in real human contact. A thorough testing protocol was subsequently developed by the FBI to evaluate penetration depth. The use of ballistic gel was the medium through which tests occurred [2,3]. Ballistic gel simulates penetration through porcine muscle (Sus scrofa), very similar to human muscle. Ballistic gel simulates human muscle as tested in porcine muscle model [4]. The FBI's special protocol indicated 12–18 inches penetration through ballistic gel would be adequate to be fatal. In the meantime, ammunition manufacturers made progress in ballistic design to comply with FBI standards [5].

To match the FBI criteria for adequate penetration, the FBI introduced a more powerful caliber, the 10 mm. However, this proved to be too powerful in recoil. They scaled down to the 40 mm ACP projectile but even this round had too much recoil. Hence the reintroduction of the now improved 9 mm projectile.

Today three manufacturers' 9 mm ammunition have become popular amongst the FBI and numerous Law Enforcement Agencies. These projectiles will be evaluated in this study.

This study approaches the question of penetration in a realistic anatomical model imitating human anatomical dimensions as close as possible. Due to ethical considerations with using cadaveric or live animal models, commercial food-grade products were sourced for experiments. The porcine model is well established and thus serves as a near human model [6].

Hypothesis

The tested 9 mm projectiles will not have enough momentum and penetration to reach the vital organs inside the thoracic cavity after contacting solid cylindrical bone.

Materials and Methods

A near human model was designed from commercial porcine tissue including an intact shoulder/humerus combined with a chest model (Fig. 1). The chest model comprised of skin, muscle (representing the pectoralis muscles), intact ribs, lung tissue, posterior ribs and skin. The ribs were positioned horizontally to imitate the human thorax. The model was built to imitate projectile penetration in a human through the shoulder (humeral bone) into the vital organs i.e. lung and exiting the distant ribs and skin. The dimensions represent the average human anatomy. The specimens were taken from commercially available porcine tissue, including a shoulder specimen ribs and lung. These models were similar in weight and size. A copy paper backstop was placed behind the models to capture a penetrating projectile. The experiment was carried out at ambient temperature, 60 °F [7].

A standard Smith and Wesson semi-automatic Performance Center Pistol with a 4.2-inch barrel was used. The shooting distance chosen was 5 yards, a very common self-defense distance. Projectile speed was measured with a QKVCX chronometer and recorded (Table 1).

After discharge of the tested round, each anatomical model was carefully dissected and photographed. Measurements of the permanent wound cavity were noted (Table 2), as well as penetration depth and bullet (projectile) construction after retrieval (Table 3). The projectile retrieved was examined and photographed (Fig. 2).

The 9 mm rounds tested included the popular three FBI / Law Enforcement rounds i.e. Hornady Critical Duty 9 mm 135 grain, Speer Gold Dot 9 mm 147 grain and Federal HST 9mm 147 grain [8]. These were all Jacketed Hollow Points (JHP), meaning the bullet (projectile) has a solid lead core covered with a copper jacket but open at the tip (Fig. 3). In case of the Hornady critical Duty the open tip was filled with a plastic red plug to prevent clogging by fibers or soft materials (Fig. 4). These rounds were tested against a modern designed solid copper fluted full metal jacketed projectile, the G9 Defense 9 mm 80 grain +P. All results were tabulated (Table1-3).

Projectile Speed in ft/s	3 Average Tested	Company Recorded
Speer Gold Dot 147 JHP	973	985
Federal HST 147 grain JHP	1016	1000
Hornady Critical Duty 135 grain JHP	1086	1070
G9 Defense 80 grain Solid Copper	1578	1520

Table 1: Projectile speed.

Projectile	Diameter
Speer Gold Dot 147 grain JHP	3 cm
Federal HST 147 grain JHP	5 cm
Hornady Critical Duty grain JHP	2 cm
G9 Defense 80 grain Solid Copper	10 cm

Table 2: Diameter of permanent wound channel in muscle.

Projectile	Depth
Speer Gold Dot 147 JHP	Only through shoulder model
Federal HST 147 grain JHP	Through both specimens into backstop
Hornady Critical Duty 135 grain JHP	Through both specimens
G9 Defense 80 grain Solid Copper	Through both models and into backstop

Table 3: Depth of Penetration

Results

Speer Gold Dot 147 gr 9 mm (JHP)

This projectile was shot through the combined model however was caught in the distal skin of the shoulder model (Fig. 5). It did not penetrate the chest model at all. The muscle wound channel was 3 cm in diameter. It shattered the long bone with multiple fragments. It expanded but also fragmented with projectile pieces found in the bone. The expansion was fragmented and suboptimal (Fig. 6).

Federal HST 147 gr 9 mm (JHP)

In the first fired projectile, it missed the bone and resulted in expected expansion of the projectile with petals (Fig. 7). The central core was intact. When shot through bone, it penetrated through the humerus and into the chest model i.e. through muscle lung and ribs. It had adequate penetration with some small fragmentation but overall remained intact. It shattered the humeral bone and caused a huge 5 cm cavity in the muscle of the chest model but retained an intact core. This projectile performed the best of the three FBI popular rounds in terms of expansion, retaining composition and depth of penetration.

Hornady Critical Duty (JHP)

This projectile completely shattered the humerus. The jacketed part completely broke off leaving only the base intact (Fig. 8). This led to a smaller, 2 cm, wound channel in the muscle. It penetrated through the chest model completely but did not enter the copy paper back stop. All the speeds recorded match the speeds published by the four companies, (Table 1).

G9 Defense round (Solid copper)

This projectile has a solid copper fluted construct. The mechanism is a screw-like action, creating a large wound channel. It shattered bone, did not fragment and penetrated through the chest model and approximately 1.4 cm into the posterior copy paper stop. The muscle cavity was the largest of all recorded i.e. 10 cm (Fig. 9,10). It had almost no damage to the tip of the projectile (Fig. 11).

Figure 1: A combined model with the shoulder model in the front and the chest model at the back. The projectile entrance is seen in the front into the shoulder model as well as the wound cavity in the chest muscle.

Figure 2: This is an example of a JHP that penetrated through bone. It fragmented and lost some of the petals. This is typical for a JHP through bone. It does not demonstrate the smooth projectile expansion of muscle penetration.

Figure 3: Federal HST an example of a jacketed hollow point with a copper jacket and a lead core.

Figure 4: Hornady Critical Duty: a Jacketed Hollow Point with a red plastic plug to prevent clogging with clothing fibers.

Figure 5: The projectile got stuck in the chest model. This is an example of a projectile that penetrated through the chest model including the humerus but did not have enough momentum to exit the chest model and therefore did not penetrate the chest model at all!

Figure 6: Another JHP that completely fragmented in bone. This picture illustrates a JHP projectile that fragmented and was located just outside a very comminuted humeral bone. It shattered the humerus shaft.

Figure 7: An example of the Federal projectile recovered after passing through soft tissue only. It shows perfect expansion of the jacket but with an intact central core as advertised on the box. This does not represent a projectile that penetrated bone.

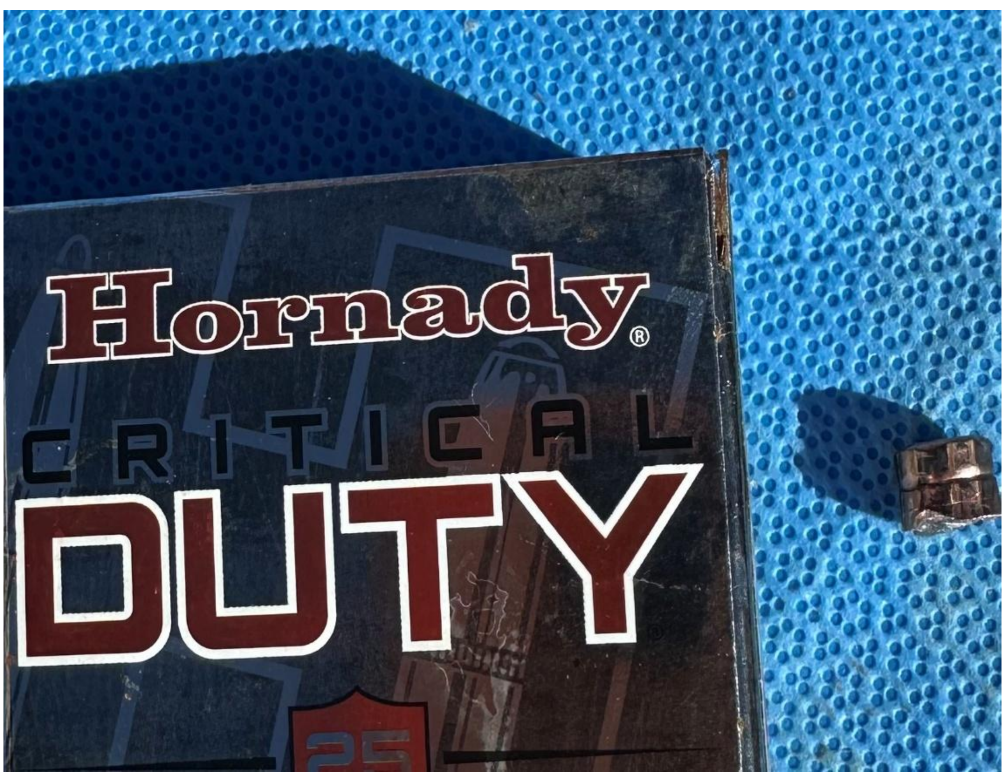

Figure 8: The full metal jacket part of the project fragmented completely off leaving only the solid base behind.

Figure 9: JHP ammunition from different manufacturers all show the same pattern i.e. non expansion and even closing up after contact with hard objects.

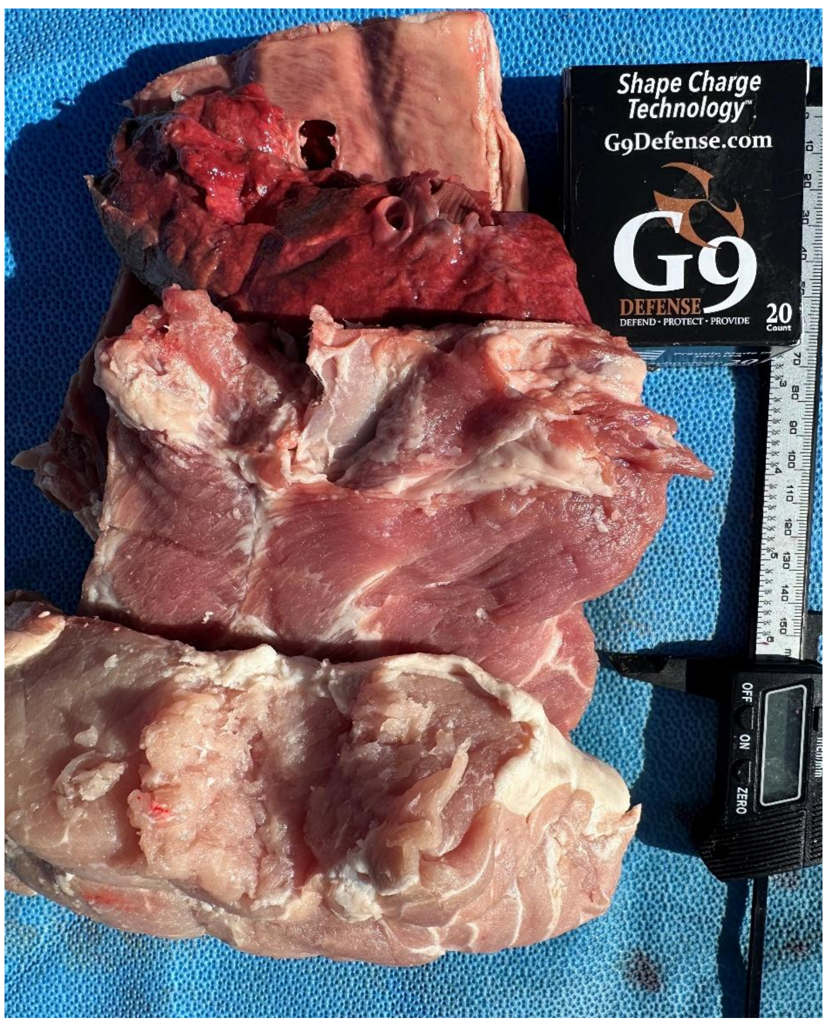

Figure 10: The G9 fluted solid copper projectile penetrating through the shoulder and through the complete chest model exiting through the posterior ribs. It demonstrates the severe permanent wound cavity through the muscle in the front.

Figure 11: The G9 solid copper fluted projectile completely intact after penetrating through the combined biological specimen i.e. the shoulder model and the chest model It was retrieved from the copy paper backstop.

Discussion

The bullet design, construction and advanced propellants matter more than caliber in the improvement of deep penetration. If a flat surface is penetrated i.e. muscle, flat bone or rib, the JHP concept of deep penetration coupled with expansion may be sound. The solid fluted copper projectile acts upon the surrounding tissue, similarly to a kitchen blender, creating a much larger wound channel that compared to the FMJ. The downside of the JHP is when it contacts a round-shaped object like cylindrical bone it begins to tilt during flight after hitting a hard object. The projectile will not expand evenly, causing it turn 180°, disintegrate or fragment partially. The metal jacket may even close instead of expanding (Fig. 9) [9]. This study confirms and illustrates the fact that the three popular FBI projectiles in the form of a JHP construct are adequate for deep penetration, causing enough damage to the vital organs to cause death [10,11]. However, if the humerus cylindrical bone is hit, only Federal HST, Hornady Critical Duty and the G9 penetrate the chest cavity simulation deep enough to be lethal (Fig. 10). The G9 penetrated the deepest and caused the most tissue damage due to its construct and solid copper composition not breaking up with deeper penetration (Fig. 11,12). The JHP is unpredictable if solid bone is encountered and may fail to penetrate deep enough to reach the vitals (Fig. 13). However in this study, Federal HST and the Hornady Critical Duty could penetrate the vitals in the chest model after fragmenting the humeral bone and despite fragmentation and inadequate expansion. For future technological development the best consistency will be found in changing from a JHP with a soft lead core to a solid fluted copper construct. Ballistic gel tests do not represent the exact complex anatomical construct of a human. Even the chest model without the shoulder model, on its own decelerates the projectile quicker than 10% ballistic gelatin [12]. Compact organs with high density but low tensile strength for instance the liver or kidneys undergo extensive damage when penetrated. This fact is well established in the literature [13-15]. Cylindrical bone however poses a completely different scenario and its impact on penetration is reported here. Neither speed nor bullet weight correlated with depth of penetration in case of the JHP projectiles. However, in case of the G9 solid copper projectile, speed, a solid construct and the fluted design of the projectile resulted in a larger wound cavity, deeper penetration and retention of construct throughout the course.

Figure 12: This photograph demonstrates the devastating damage of the humeral shaft due to a G9 projectile. The intact projectile is shown in Fig. 11.

Figure 13: Here are 4 examples where no expansion occurred. Clogging with a soft material took place. Smooth expansion did not take place when hard surfaces were met.

Conclusion

Our hypothesis was partially correct. Not all JHP projectiles will be lethal in a near human simulation after penetrating solid bone. However, the solid fluted copper model resulted in the deepest penetration combined with the largest extent of the permanent wound channel despite its smaller weight. This realistic anatomical model attests to the unpredictability of especially a JHP after being in contact with a hard, curved object. The near human experimental model used in our study also confirms utilizing simulation models will not correlate to the complexity of a biological model utilizing real life shooting scenarios. The FBI with criteria for sufficient penetration depth in the human only applies to muscle but does not correlate to a cylindrical bone penetration.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethical Statement

All porcine products were sourced from commercial food grade sources. Due to the sourcing of the material no IRB/IACUC approval is required as no living animals were manipulated or experimented on at any time.

Informed Consent Statement

Informed consent was obtained from all participants included in the study.

Authors' Contributions

All authors contributed equally to this paper.

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