

Wound Ballistics 101

By Paul Gomez

Having had to go through these ideas step-by-step on more than one occasion, I've found this to be a useful way to get the correct data out there in an easily digestible format. What follows are individual sections from the IWBA Handgun Ammunition Specification Package [henceforth IWBA] and the FBI paper on Handgun Wounding Factors and Effectiveness [heretofore FBI].

IWBA: 6.1.2

Most physicians knowledgeable in wound trauma believe that adequate penetration depth is the most important single property in handgun ammunition. The appropriate value for minimum penetration depth has generally been assumed to be 12 inches ever since the first FBI wound ballistics meeting in 1987. Unfortunately, this assumption has often been interpreted very simplistically (i.e., 12.1 Inches of penetration is good, but 11.9 inches of penetration is no good), but the real situation is more complicated. The problem is the possibility that the bullet will require an unusually large penetration to reach vital structures well inside the body. This can occur when the bullet must traverse non-critical tissue; e.g., the extended arm of an assailant aiming his handgun, and/or an unusual bullet path angle in the torso, and/or an unusually fat or beefy individual. The probability of needing this extra penetration is a judgment call, but most people believe it is a significant factor and much more important than the relatively modest increase in expanded diameter achieved by reducing penetration depth (e.g., approximately 30% increase in expanded bullet diameter is achieved by designing to an 8 inch penetration depth rather than 12 inches). This is the reason the professional wound ballistics community specified the 12 inch minimum penetration even though they are well aware that an 8 inch penetration is usually adequate. The suggested specification values for mean penetration depth are greater than 12.5 inches and less than 14.0 inches. Even at the limit of minimum value of this range (12.5 inches) and the limiting value of standard deviation (0.6) in Section 6.1.1, about 80% of the penetration will be greater than 12 inches and essentially all will be greater than 11 inches. This bare gelatin test provides a lower limit on penetration because most shootings will involve at least some clothing; slightly less expansion and slightly deeper penetration can be expected in typical service use.

IWBA: 6.1.3

This specification is included to prevent unsound bullet designs that over expand and break up (which reduces effectiveness in handgun bullets) or bullet designs that tend to separate the jacket early in the penetration. Some bullet designs occasionally shed their jackets near the end of the penetration; this is not desirable, but shedding the jacket after about 12 inches of penetration is not a serious flaw. Note that tests have shown that bullet expansion in bare gelatin will

usually be slightly greater than expansion in tissue; the theoretical basis for this slight difference is understood. As a result, bullet designs that do not break up in bare gelatin are unlikely to break up in soft tissue.

IWBA: 6.2

Most expansion failures of JHP handgun bullets reported in actual shootings where hard barriers are not involved are probably due to factors that effectively plug up the hollow point cavity and reduce pressure in this area, although the dynamics model that occasionally leads to this result is not completely known in detail. This requirement in the IWBA Handgun Ammunition Specification is designed to force JHP bullet designs that expand much more reliably against soft barriers (hard barriers are discussed in more detail below). This requirement was selected after experimentation to provide a standardized, inexpensive, and precisely defined soft barrier that was a stressing but reasonable protocol for ammunition evaluation; it does not represent a simulation of specific clothing. The JHP bullet design features required to satisfy this requirement are well understood, and ammunition having these design features expands much more consistently and reliably against soft barriers than ammunition without these design features.

IWBA: 6.2.1

The standard deviation of the penetration depth is the best measure of consistency of bullet expansion, and is an important indication of the quality of bullet design. The standard deviation in this section can be expected to be somewhat larger than in Section 6.1.1 (bare gelatin), but should still be reasonably small with well designed bullets. The recommended value of this parameter is 0.8 inch. Specification of (or acceptance of) a slightly larger value (e.g., 1.0 inch) does not have serious performance consequences (see discussion under Section 6.0).

IWBA: 6.2.2

The mean penetration depth in this section can be expected to be somewhat larger than in Section 6.1.2 (bare gelatin), and represents a reasonable upper bound on the mean penetration depth in service. The suggested specification values for mean penetration depth are greater than 13.0 inches and less than 16.0 inches. The realities of JHP bullet performance eliminate any practical concern that penetration depth will be inadequate in this test for any ammunition with adequate penetration in the Section 6.1 test. A one inch increase in maximum penetration depth corresponds to approximately a 0.02 inch reduction in expanded diameter, which is not a significant concern as long as the requirement of Section 6.2.1 is met. The general discussion of penetration depth in Section 6.1.2 also applies here.

IWBA: Comments on Expanded JHP Bullet Diameter

The absence of any mention of expanded JHP diameter in the IWBA specification is not an oversight, expanded JHP bullet diameter is omitted because it is not independent of penetration depth. A JHP bullet of any weight, velocity, and penetration depth has an effective expanded diameter that produces the forces on the tissue during bullet penetration, and this effective diameter cannot be changed without changing at least one of the other parameters. In effect, bullet weight, velocity and penetration depth define the effective expanded bullet diameter. Penetration depth is easy and unambiguous to measure, but effective expanded bullet diameter is difficult to estimate with useful accuracy because the expanded periphery is inevitably irregular and not easily related to the effective expanded diameter. As a result, measured expanded bullet diameter is much less useful than penetration depth as a performance parameter in an ammunition specification. As a rule of thumb, effective expanded diameter is about 50% to 60% larger than original JHP bullet diameter when penetration is adequate. If bullet weight, velocity and penetration depth are specified, effective bullet diameter can be "required" to be any value not greater than it actually is, but this is pointless. There is no point in "requiring" effective expanded bullet diameter to be larger than allowed by the dynamics of penetration.

FBI: Mechanics of Projectile Wounding

In order to predict the likelihood of incapacitation with any handgun round, an understanding of the mechanics of wounding is necessary. There are four components of projectile wounding.⁶ Not all of these components relate to incapacitation, but each of them must be considered. They are:

- (1) Penetration. The tissue through which the projectile passes, and which it disrupts or destroys.
- (2) Permanent Cavity. The volume of space once occupied by tissue that has been destroyed by the passage of the projectile. This is a function of penetration and the frontal area of the projectile. Quite simply, it is the hole left by the passage of the bullet.
- (3) Temporary Cavity. The expansion of the permanent cavity by stretching due to the transfer of kinetic energy during the projectile's passage.
- (4) Fragmentation. Projectile pieces or secondary fragments of bone which are impelled outward from the permanent cavity and may sever muscle tissues, blood vessels, etc., apart from the permanent cavity. Fragmentation is not necessarily present in every projectile wound. It may, or may not, occur and can be considered a secondary effect.

Projectiles incapacitate by damaging or destroying the central nervous system, or by causing lethal blood loss. To the extent the wound components cause or increase the effects of these two mechanisms, the likelihood of incapacitation increases. Because of the impracticality of training for head shots, this examination of handgun wounding relative to law enforcement use is focused upon torso wounds and the probable results.

FBI: Mechanics of Handgun Wounding

All handgun wounds will combine the components of penetration, permanent cavity, and temporary cavity to a greater or lesser degree. Fragmentation, on the other hand, does not reliably occur in handgun wounds due to the relatively low velocities of handgun bullets. Fragmentation occurs reliably in high velocity projectile wounds (impact velocity in excess of 2000 feet per second) inflicted by soft or hollow point bullets. In such a case, the permanent cavity is stretched so far, and so fast, that tearing and rupturing can occur in tissues surrounding the wound channel which were weakened by fragmentation damage. It can significantly increase damage in rifle bullet wounds.

Since the highest handgun velocities generally do not exceed 1400-1500 feet per second (fps) at the muzzle, reliable fragmentation could only be achieved by constructing a bullet so frangible as to eliminate any reasonable penetration. Unfortunately, such a bullet will break up too fast to penetrate to vital organs. The best example is the Glaser Safety Slug, a projectile designed to break up on impact and generate a large but shallow temporary cavity. Fackler, when asked to estimate the survival time of someone shot in the front mid-abdomen with a Glaser slug, responded, "About three days, and the cause of death would be peritonitis."

In cases where some fragmentation has occurred in handgun wounds, the bullet fragments are generally found within one centimeter of the permanent cavity. "The velocity of pistol bullets, even of the new high-velocity loadings, is insufficient to cause the shedding of lead fragments seen with rifle bullets." It is obvious that any additional wounding effect caused by such fragmentation in a handgun wound is inconsequential.

FBI: The Human Target

With the exceptions of hits to the brain or upper spinal cord, the concept of reliable and reproducible immediate incapacitation of the human target by gunshot wounds to the torso is a myth. The human target is a complex and durable one. A wide variety of psychological, physical, and physiological factors exist, all of them pertinent to the probability of incapacitation. However, except for the location of the wound and the amount of tissue destroyed, none of the factors

are within the control of the law enforcement officer.

Physiologically, a determined adversary can be stopped reliably and immediately only by a shot that disrupts the brain or upper spinal cord. Failing a hit to the central nervous system, massive bleeding from holes in the heart or major blood vessels of the torso causing circulatory collapse is the only other way to force incapacitation upon an adversary, and this takes time. For example, there is sufficient oxygen within the brain to support full, voluntary action for 10-15 seconds after the heart has been destroyed.

In fact, physiological factors may actually play a relatively minor role in achieving rapid incapacitation. Barring central nervous system hits, there is no physiological reason for an individual to be incapacitated by even a fatal wound, until blood loss is sufficient to drop blood pressure and/or the brain is deprived of oxygen. The effects of pain, which could contribute greatly to incapacitation, are commonly delayed in the aftermath of serious injury such as a gunshot wound. The body engages survival patterns, the well known "fight or flight" syndrome. Pain is irrelevant to survival and is commonly suppressed until some time later. In order to be a factor, pain must first be perceived, and second must cause an emotional response. In many individuals, pain is ignored even when perceived, or the response is anger and increased resistance, not surrender.

Psychological factors are probably the most important relative to achieving rapid incapacitation from a gunshot wound to the torso. Awareness of the injury (often delayed by the suppression of pain); fear of injury, death, blood, or pain; intimidation by the weapon or the act of being shot; preconceived notions of what people do when they are shot; or the simple desire to quit can all lead to rapid incapacitation even from minor wounds. However, psychological factors are also the primary cause of incapacitation failures.

The individual may be unaware of the wound and thus has no stimuli to force a reaction. Strong will, survival instinct, or sheer emotion such as rage or hate can keep a grievously injured individual fighting, as is common on the battlefield and in the street. The effects of chemicals can be powerful stimuli preventing incapacitation. Adrenaline alone can be sufficient to keep a mortally wounded adversary functioning. Stimulants, anesthetics, pain killers, or tranquilizers can all prevent incapacitation by suppressing pain, awareness of the injury, or eliminating any concerns over the injury. Drugs such as cocaine, PCP, and heroin are disassociative in nature. One of their effects is that the individual "exists" outside of his body. He sees and experiences what happens to his body, but as an outside observer who can be unaffected by it yet continue to use the body as a tool for fighting or resisting.

Psychological factors such as energy deposit, momentum transfer, size of temporary cavity or calculations such as the RII are irrelevant or erroneous. The impact of the bullet upon the body is no more than the recoil of the weapon. The

ratio of bullet mass to target mass is too extreme.

The often referred to "knock-down power" implies the ability of a bullet to move its target. This is nothing more than momentum of the bullet. It is the transfer of momentum that will cause a target to move in response to the blow received. "Isaac Newton proved this to be the case mathematically in the 17th Century, and Benjamin Robins verified it experimentally through the invention and use of the ballistic pendulum to determine muzzle velocity by measurement of the pendulum motion."

Goddard amply proves the fallacy of "knock-down power" by calculating the heights (and resultant velocities) from which a one pound weight and a ten pound weight must be dropped to equal the momentum of 9mm and .45ACP projectiles at muzzle velocities, respectively. The results are revealing. In order to equal the impact of a 9mm bullet at its muzzle velocity, a one pound weight must be dropped from a height of 5.96 feet, achieving a velocity of 19.6 fps. To equal the impact of a .45ACP bullet, the one pound weight needs a velocity of 27.1 fps and must be dropped from a height of 11.4 feet. A ten pound weight equals the impact of a 9mm bullet when dropped from a height of 0.72 inches (velocity attained is 1.96 fps), and equals the impact of a .45 when dropped from 1.37 inches (achieving a velocity of 2.71 fps).

A bullet simply cannot knock a man down. If it had the energy to do so, then equal energy would be applied against the shooter and he too would be knocked down. This is simple physics, and has been known for hundreds of years. The amount of energy deposited in the body by a bullet is approximately equivalent to being hit with a baseball. Tissue damage is the only physical link to incapacitation within the desired time frame, i.e., instantaneously.

The human target can be reliably incapacitated only by disrupting or destroying the brain or upper spinal cord. Absent that, incapacitation is subject to a host of variables, the most important of which are beyond the control of the shooter. Incapacitation becomes an eventual event, not necessarily an immediate one. If the psychological factors which can contribute to incapacitation are present, even a minor wound can be immediately incapacitating. If they are not present, incapacitation can be significantly delayed even with major, unsurvivable wounds.

Field results are a collection of individualistic reactions on the part of each person shot which can be analyzed and reported as percentages. However, no individual responds as a percentage, but as an all or none phenomenon which the officer cannot possibly predict, and which may provide misleading data upon which to predict ammunition performance.

FBI: The Allure of Shooting Incident Analyses

There is no valid, scientific analysis of actual shooting results in existence, or being pursued to date. It is an unfortunate vacuum because a wealth of data exists, and new data is being sadly generated every day. There are some well publicized, so called analyses of shooting incidents being promoted, however, they are greatly flawed. Conclusions are reached based on samples so small that they are meaningless. The author of one, for example, extols the virtues of his favorite cartridge because he has collected ten cases of one shot stops with it. Preconceived notions are made the basic assumptions on which shootings are categorized. Shooting incidents are selectively added to the "data base" with no indication of how many may have been passed over or why. There is no correlation between hits, results, and the location of the hits upon vital organs.

It would be interesting to trace a life-sized anatomical drawing on the back of a target, fire 20 rounds at the "center of mass" of the front, then count how many of these optimal, center of mass hits actually struck the heart, aorta, vena cava, or liver. It is rapid hemorrhage from these organs that will best increase the likelihood of incapacitation. Yet nowhere in the popular press extolling these studies of real shootings are we told what the bullets hit.

These so called studies are further promoted as being somehow better and more valid than the work being done by trained researchers, surgeons and forensic labs. They disparage laboratory stuff, claiming that the "street" is the real laboratory and their collection of results from the street is the real measure of caliber effectiveness, as interpreted by them, of course. Yet their data from the street is collected haphazardly, lacking scientific method and controls, with no noticeable attempt to verify the less than reliable accounts of the participants with actual investigative or forensic reports. Cases are subjectively selected (how many are not included because they do not fit the assumptions made?). The numbers of cases cited are statistically meaningless, and the underlying assumptions upon which the collection of information and its interpretation are based are themselves based on myths such as knock-down power, energy transfer, hydrostatic shock, or the temporary cavity methodology of flawed work such as RII.

Further, it appears that many people are predisposed to fall down when shot. This phenomenon is independent of caliber, bullet, or hit location, and is beyond the control of the shooter. It can only be proven in the act, not predicted. It requires only two factors to be effected: a shot and cognition of being shot by the target. Lacking either one, people are not at all predisposed to fall down and don't. Given this predisposition, the choice of caliber and bullet is essentially irrelevant. People largely fall down when shot, and the apparent predisposition to do so exists with equal force among the good guys as among the bad. The causative factors are most likely psychological in origin. Thousands of books, movies and television shows have educated the general population that when

shot, one is supposed to fall down.

The problem, and the reason for seeking a better cartridge for incapacitation, is that individual who is not predisposed to fall down. Or the one who is simply unaware of having been shot by virtue of alcohol, adrenaline, narcotics, or the simple fact that in most cases of grievous injury the body suppresses pain for a period of time. Lacking pain, there may be no physiological effect of being shot that can make one aware of the wound. Thus the real problem: if such an individual is threatening one's life, how best to compel him to stop by shooting him?

The factors governing incapacitation of the human target are many, and variable. The actual destruction caused by any small arms projectile is too small in magnitude relative to the mass and complexity of the target. If a bullet destroys about 2 ounces of tissue in its passage through the body, that represents 0.07 of one percent of the mass of a 180 pound man. Unless the tissue destroyed is located within the critical areas of the central nervous system, it is physiologically insufficient to force incapacitation upon the unwilling target. It may certainly prove to be lethal, but a body count is no evidence of incapacitation. Probably more people in this country have been killed by .22 rimfires than all other calibers combined, which, based on body count, would compel the use of .22's for self-defense. The more important question, which is sadly seldom asked, is what did the individual do when hit?

There is a problem in trying to assess calibers by small numbers of shootings. For example, as has been done, if a number of shootings were collected in which only one hit was attained and the percentage of one shot stops was then calculated, it would appear to be a valid system. However, if a large number of people are predisposed to fall down, the actual caliber and bullet are irrelevant. What percentage of those stops was thus preordained by the target? How many of those targets were not at all disposed to fall down? How many multiple shot failures to stop occurred? What is the definition of a stop? What did the successful bullets hit and what did the unsuccessful bullets hit? How many failures were in the vital organs, and how many were not? How many of the successes? What is the number of the sample? How were the cases collected? What verifications were made to validate the information? How can the verifications be checked by independent investigation?

Because of the extreme number of variables within the human target, and within shooting situations in general, even a hundred shootings is statistically insignificant. If anything can happen, then anything will happen, and it is just as likely to occur in your ten shootings as in ten shootings spread over a thousand incidents. Large sample populations are absolutely necessary.

Here is an example that illustrates how erroneous small samples can be. I flipped a penny 20 times. It came up heads five times. A nickel flipped 20 times showed

heads 8 times. A dime came up heads 10 times and a quarter 15 times. That means if heads is the desired result, a penny will give it to you 25% of the time, and nickel 40% of the time, a dime 50% of the time and a quarter 75% of the time. If you want heads, flip a quarter. If you want tails, flip a penny. But then I flipped the quarter another 20 times and it showed heads 9 times - 45% of the time. Now this "study" would tell you that perhaps a dime was better for flipping heads. The whole thing is obviously wrong, but shows how small numbers lead to statistical lies. We know the odds of getting a head or tail are 50%, and larger numbers tend to prove it. Calculating the results for all 100 flips regardless of the coin used shows heads came up 48% of the time.

The greater the number and complexity of the variables, the greater the sample needed to give meaningful information, and a coin toss has only one simple variable – it can land heads or it can land tails. The coin population is not complicated by a predisposition to fall one way or the other, by chemical stimuli, psychological factors, shot placement, bone or obstructive obstacles, etc.; all of which require even larger numbers to evidence real differences in effects.

Although no cartridge is certain to work all the time, surely some will work more often than others, and any edge is desirable in one's self defense. This is simple logic. The incidence of failure to incapacitate will vary with the severity of the wound inflicted. It is safe to assume that if a target is always 100% destroyed, then incapacitation will also occur 100% of the time. If 50% of the target is destroyed, incapacitation will occur less reliably. Failure to incapacitate is rare in such a case, but it can happen, and in fact has happened on the battlefield. Incapacitation is still less rare if 25% of the target is destroyed. Now the magnitude of bullet destruction is far less (less than 1% of the target) but the relationship is unavoidable. The round which destroys 0.07% of the target will incapacitate more often than the one which destroys 0.04%. However, only very large numbers of shooting incidents will prove it. The difference may be only 10 out of a thousand, but that difference is an edge, and that edge should be on the officer's side because one of those ten may be the subject trying to kill him.

FBI: The Allure of Shooting Incident Analyses, PT 2

To judge a caliber's effectiveness, consider how many people hit with it failed to fall down and look at where they were hit. Of the successes and failures, analyze how many were hit in vital organs, rather than how many were killed or not, and correlate that with an account of exactly what they did when they were hit. Did they fall down, or did they run, fight, shoot, hide, crawl, stare, shrug, give up and surrender? ONLY falling down is good. All other reactions are failures to incapacitate, evidencing the ability to act with volition, and thus able to choose to continue to try to inflict harm.

Those who disparage science and laboratory methods are either too short

sighted or too bound by preconceived (or perhaps proprietary) notions to see the truth. The labs and scientists do not offer sure things. They offer a means of indexing the damage done by a bullet, understanding of the mechanics of damage caused by bullets and the actual effects on the body, and the basis for making an informed choice based on objective criteria and significant statistics.

The differences between bullets may be small, but science can give us the means of identifying that difference. The result is the edge all of law enforcement should be looking for. It is true that the streets are the proving ground, but gives me an idea of what you want to prove and I will give you ten shootings from the street to prove it. That is both easy, and irrelevant. If it can happen, it will happen.

Any shooting incident is a unique event, unconstrained by any natural law or physical order to follow a predetermined sequence of events or end in predetermined results. What is needed is an edge that makes the good result more probable than the bad. Science will quantify the information needed to make the choice to gain that edge. Large numbers (thousands or more) from the street will provide the answer to the question "How much of an edge?" Even if that edge is only 1%, it is not insignificant because the guy trying to kill you could be in that 1% and you won't know it until it is too late.

FBI: Conclusions

Physiologically, no caliber or bullet is certain to incapacitate any individual unless the brain is hit. Psychologically, some individuals can be incapacitated by minor or small caliber wounds. Those individuals who are stimulated by fear, adrenaline, drugs, alcohol, and/or sheer will and survival determination may not be incapacitated even if mortally wounded.

The will to survive and to fight despite horrific damage to the body is commonplace on the battlefield, and on the street. Barring a hit to the brain, the only way to force incapacitation is to cause sufficient blood loss that the subject can no longer function, and that takes time. Even if the heart is instantly destroyed, there is sufficient oxygen in the brain to support full and complete voluntary action for 10-15 seconds.

Kinetic energy does not wound. Temporary cavity does not wound. The much discussed "shock" of bullet impact is a fable and "knock down" power is a myth. The critical element is penetration. The bullet must pass through the large, blood bearing organs and be of sufficient diameter to promote rapid bleeding. Penetration less than 12 inches is too little, and, in the words of two of the participants in the 1987 Wound Ballistics Workshop, "too little penetration will get you killed." Given desirable and reliable penetration, the only way to increase bullet effectiveness is to increase the severity of the wound by increasing the size of hole made by the bullet. Any bullet which will not penetrate through vital

organs from less than optimal angles is not acceptable. Of those that will penetrate, the edge is always with the bigger bullet.

The FBI paper dates from 1989 following the second Wound Ballistics Conference called by them following the 1986 event most often referred to as the "Miami Massacre".

The IWBA paper is a more current document [originating in 1998] intended to update the test protocols to force continued evolution in bullet design.

An easy 'rule of thumb' is to go with a major brand and the heaviest bullet weight in a given calibre. That equates to 147gr/9mm, 180gr/.40, 230gr/.45, but there are some oddballs that give very good performance while being at odd with this.

Both are available, in full, at www.firearmstactical.com and should be studied by everyone serious about understanding what bullets do to bodies and choosing effective ammunition.

Examples of current production ammunition which meets the IWBA test protocols, per Dr. Gary K. Roberts, are:

9 mm:

Barnes 105 gr JHP (copper bullet)
Fed 124 gr JHP (LE9T1)
Speer 124 gr +P JHP (53617)
Win 124 gr JHP (RA91P)
Win 127 gr +P+ JHP (RA9TA)
Fed 135 gr +P JHP (LE9T5)
Rem 147 gr JHP (GS9MMC)
Speer 147 gr JHP (53619)
Win 147 gr JHP (RA9T)

.40 S&W:

Speer 155 gr JHP (53961)
Fed 165 gr JHP (LE40T3)
Win 165 gr JHP (RA40TA)
Win 165 gr JHP (RA401P)
Fed 180 gr JHP (LE40T1)
Rem 180 gr JHP (GS40SWB)
Speer 180 gr JHP (53966)
Win 180 gr JHP (RA40T)

.45 ACP:

Barnes/Taurus 185 gr JHP
Federal 230 gr Tactical (LE45T1)
Speer 230 gr Gold Dot (23966).

Winchester 230 gr Ranger Talon (RA45T)
Winchester 230 gr +P Ranger Talon (RA45TP)

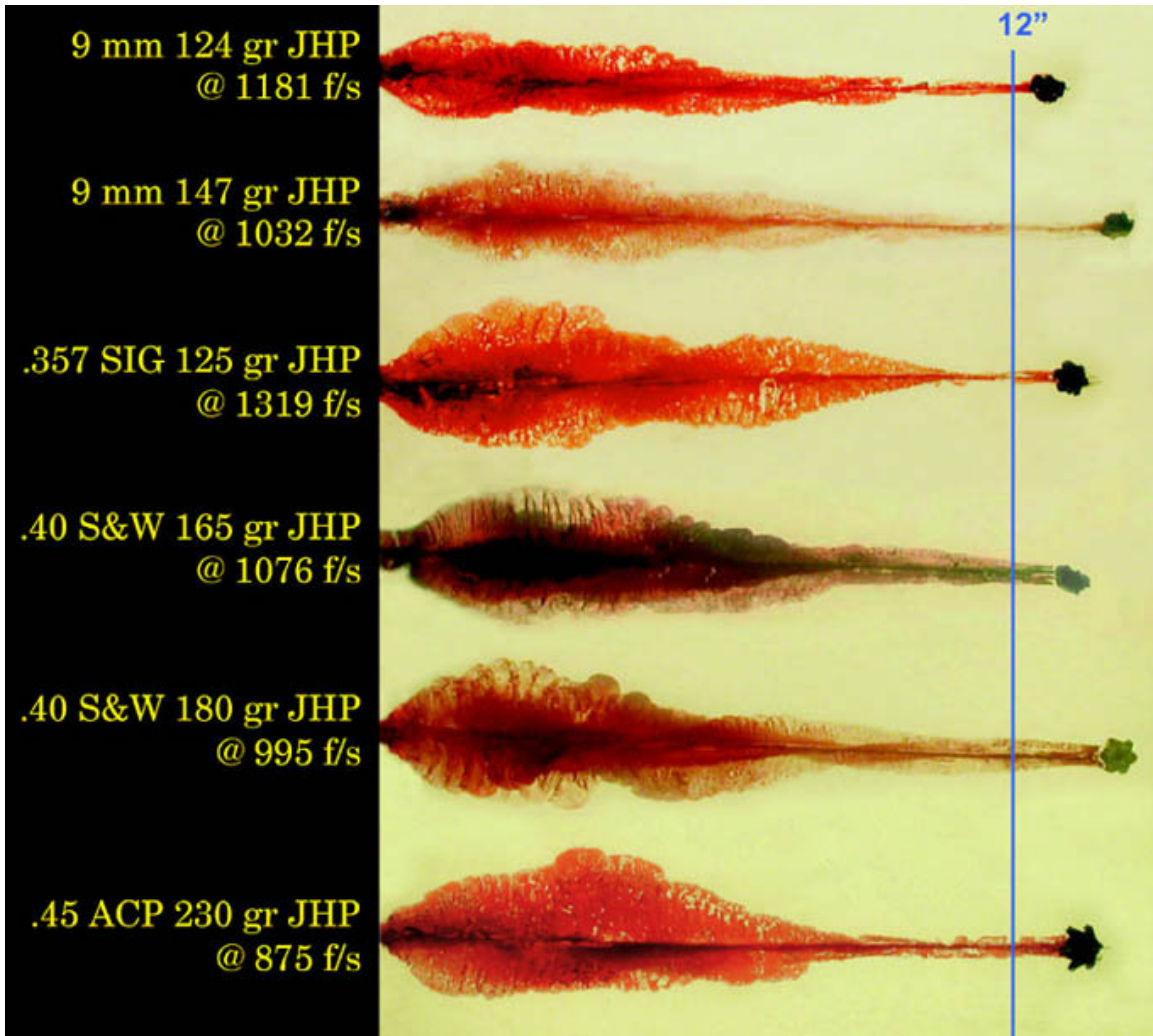
The keys are: -- Cultivate a warrior mindset
-- Invest in competent, thorough initial training and then maintain skills with regular ongoing practice
-- Acquire a reliable and durable weapon system
-- Purchase a consistent, robust performing duty load in sufficient quantities (at least 1000 rounds) then **STOP** worrying about the nuances of handgun ammunition terminal performance.

Here are a couple of pictures, again, courtesy of DocGKR:

First, 9mm, .357 Sig, .40S&W and .45ACP projectiles recovered from calibrated gelatin. Notice the greatest difference is only .12-inch...



And here's a pic of the common calibers showing penetration in calibrated gelatin. Again, courtesy of Doctor Roberts



Shotgun & Rifle Information Added by M. Driscoll

Shotgun fun:

Tests with #7 & 1/2, #4 and 0 buckshot.

<http://www.cprc.org/tr/tr-1998-03.pdf>

The scoop on what to look for in rifle ammunition, courtesy of Dr. Gary Roberts

(This also assumes properly prepared, sized and calibrated Gelatin)

