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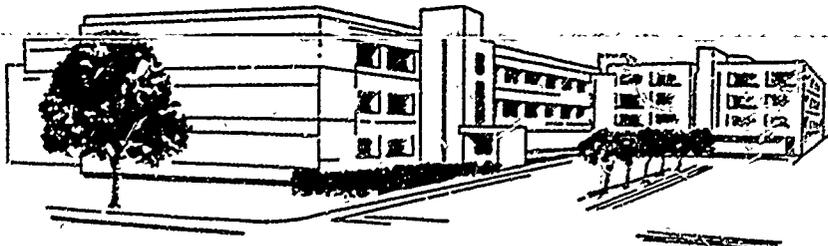
**Wound Ballistics Research of the Past
Twenty Years: A Giant Step Backwards**

Martin L. Fackler

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Wound Ballistics Research of the Past Twenty Years: A Giant Step Backwards
(Military Trauma Report 447) -- ML Fackler

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Historically, this type of wound has healed well, despite little or no treatment -- even in preantibiotic days.

Since the Vietnam era, the bulk of wound ballistics "research" has been politically motivated. This research has employed flawed methods to exaggerate wounding effects, seriously confusing current wound treatment doctrine. The battlefield surgeon determines treatment according to the amount, type and location of disruption, rather than the supposed velocity of the projectile.

ABSTRACT

Wound ballistics research is supposed to aid the surgeon in providing optimal care for the wounded, but recent trends in ballistics research have not provided the surgeon with objectively determined information. Twenty years ago, wounds from penetrating projectiles were likely to be treated in a rational and effective manner; today many surgeons are prone to remove excessive amounts of tissue when treating wounds caused by what they assume to be "high-velocity" projectiles.

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WOUND BALLISTICS RESEARCH OF THE PAST TWENTY YEARS: A GIANT STEP BACKWARDS

INTRODUCTION

The widespread misconception that "high-velocity" or "high-energy" projectiles invariably cause extensive damage (1,2) has been addressed recently (3,4). In the past, critical reviews questioning this concept have gone relatively unheeded (5,6). Interestingly, those who have questioned the "high-velocity/high-energy" concept of wounding (Lindsey, Hampton, Fackler) have all had extensive combat surgery experience.

Multiple penetrations by fragments from explosive devices are a common injury in most armed conflicts. Figure 1 shows a soldier who has suffered multiple fragment wounds. Fragments generally penetrate less than 15 cm in human soft-tissue; they cause a punctate entrance wound and track consistent with their size. Tissue surrounding their track is uninjured. Figure 2 shows the wounding pattern produced by a steel sphere; fragments from explosive devices produce similar wounding patterns, with the maximum disruption near the entrance where the projectile velocity is greatest. The last 15 cm of projectile penetration shown in Figure 2 produces no significant temporary cavitation because the velocity of the projectile decreases with penetration. This last portion of the projectile path illustrates the typical battlefield fragment wound. Military rifle bullets cause this same type of wound, with negligible cavitation, in the first part of their path through tissue, before the bullet yaws. Figure 3 shows wound profiles produced by two common military rifle bullets compared with those produced by projectiles of lesser velocity. Note that the disruption produced in the first part of their path, the only part involved in most extremity wounds, does not differ significantly from that produced by the far lower velocity bullets. Thousands of these simple perforations of the extremity (Fig. 4) are seen each year in our larger city civilian hospitals; the great majority of these wounds are treated with systemic antibiotics but little or no surgery as they heal well (5).

HISTORICAL REVIEW

Before the wound ballistics research that followed the Vietnam conflict, uncomplicated military rifle wounds (and small fragment wounds for the most part) were also treated with little or no surgery because they healed well. Compare Stevenson's advice in 1897 (7) against surgical interference with the bullet path

in rifle wounds, with Theodor Kocher's observations from World War I (8), that the minimal damage produced by the rifle bullet allowed the wounds ("...wie Verletzungen ohne hautwunde ausheilten.") to heal so well that it appeared as if they had no skin wounds.

Jolly, in 1941 (9), noted,

Many high-velocity bullet wounds of soft parts have small punctured wounds of entrance and exit. Often such wounds do not require operation; and if operation is performed, nothing more than excision of the orifices of the track to provide better drainage need be undertaken. Such wounds usually heal spontaneously within ten days. The high velocity bullet, unlike other projectiles, does not usually carry foreign matter into the tissues and tends to leave an aseptic track.

Bailey, in 1942 (10), advised that the "...seton wound is innocuous, it should be left alone." Ferguson et al. (11), Slesinger (12), Crile (13), and Cope (14) made similar observations, and Ogilvie (15), consultant surgeon to British forces in World War II, listed as his first "sin" of war surgery the unnecessary operations on through and through bullet wounds of the soft parts. He wrote, "The majority of these with rest and sulfonamide heal rapidly and leave no disability; operation means loss of time and loss of function."

King (16), reporting on war wounds from South Vietnam, wrote that "Uncomplicated perforating soft-tissue wounds were the most common bullet wounds of the extremities. They showed small entry and exit wounds and a clear soft-tissue track with little or no devitalization of tissue. They usually healed if left alone."

The author of this paper served in one of the busiest hospitals in South Vietnam (US Naval Support Activity Hospital, DaNang) during the most active period of the Vietnam conflict (December 1967 to December 1968). Immediately thereafter he served three years at the US Naval Hospital, Yokosuka, Japan, caring for the combat casualties from South Vietnam who were transported there by air soon after initial surgery. He was also a delegate at the last two Tri-Service War Surgery Conferences (1970, 1971) (17). The author and his colleagues determine the treatment of penetrating

war wounds by assessing the amount, type, and location of tissue disruption, evidenced by physical examination and appropriate x-ray studies (17).

ORIGINS OF CURRENT MISCONCEPTIONS

If we had no trouble treating the gunshot wounds of the Vietnam War, why has this field regressed so badly since then? In 1967, one small series of wounds caused by the then new M-16 assault rifle was reported (18,19). These wounds were described using such emotionally charged terms such as "massively destructive" (18) and "devastating wounding power...tremendous wounding and killing power" (19) rather than reporting wound dimensions and/or including measuring scales on photographs to give the reader an objective means of comparing these wounds with those caused by other weapons.

Remembering the political climate of that time, and the fact that the Swedish government, as a part of its anti-war stance, was actively encouraging desertion by American soldiers and providing them refuge, it is not surprising that Swedish interests saw an opportunity to be exploited in these reports. They began a program to declare the M-16 "inhuman" and to be outlawed by international convention. The "research" performed to support this program used methods of easily misinterpreted to make wounding effects of by the M-16 bullet appear worse than those of other small-arms projectiles. For example, shocking projectiles through small (14 cm) blocks of tissue simulant or the legs of 20 kg pigs in which the tissue path is even shorter, can provide results which are misleading. The photos in Berlin, et al. (20) show a 15 cm stellate exit wound caused by a 5.56 mm bullet compared to an exit wound of only about 1 cm caused by a 7.62 mm bullet, thereby making the smaller bullet appear to have a far greater wounding capacity.

Military bullets begin their tissue path traveling point forward. They yaw (turn sideways in relation to their line of flight) at a penetration depth under 10 cm to over 20 cm, depending upon the bullet. Even in groups of shots using the same type of bullet, variations in the penetration depth at which the bullet yaws can easily vary 25% from the average (21). This means that in any group of shots with a given bullet there are likely to be some that yaw within these small targets; these will show large exit wounds. There will be others that have not yet yawed; these will show

minimal wounds. Individuals with an interest in "proving" one bullet less "humane" than another need only to photograph the appropriate exit wound. This variation in yawing distance also explains apparent inconsistencies in bullet effects. Nordstrand, et al. (22), showed comparative microsecond x-ray pictures comparing the same type bullets (5.56 and 7.62) for which Berlin et al. (20) had indicated an apparently far greater wounding effect for the 5.56 mm bullet. In the Nordstrand study (22), both bullets yawed and broke apart at the same depth of penetration in a soap block, and the 7.62 mm bullet's disruptive effects were far greater.

By using enough tissue/tissue simulant to catch the entire projectile path, the entire potential of the projectile can be determined (23); nothing is hidden. Only presentation of the projectile's disruption pattern along its entire tissue path allows meaningful comparison of wounding potential among various projectiles.

Apparently overzealous in his attempt to justify the Swedish efforts, Berlin wrote, "During the 1960's injuries of much greater severity were reported due to a new generation of small firearms." (24). Those who wish to check will find that only two of the seven citations Berlin gives to support that statement do, in fact, support it; these two are by the same author (18). In fact, it appears that all the furor over the M-16, repeated and amplified in many papers, originated from this one source (18).

OBJECTIVE OBSERVERS SAW NO MORE SEVERE WOUNDS FROM THE M-16 THAN FROM OTHER SMALL-ARMS

The five Tri-Service Vietnam war surgery conferences did not identify any special problems associated with "high-velocity" projectile wounds. The last conference (17) listed "Topics suggested for further study," but no need to study penetrating projectiles (wound ballistics) was mentioned.

Scott (25), in a superbly comprehensive study which combined an outstanding historical review, comparative shots into tissue simulant and live animals at ranges up to 600 m, as well as case reports of 70 shootings with the new 5.56 mm caliber, concluded, "The experimental observations which I have made under widely varying circumstances do not indicate that light weight rifle bullets inflict more severe wounds than

those caused by rifles in use since the early part of this century. My experience in the field supports this conclusion."

Albrecht et al. (26) did an extensive study shooting various military rifle bullets through the tied-together thighs of 59-66 kg swine to study bullet effects in a more realistic tissue thickness (25 cm) than was used in the Swedish studies. Their findings were clear; the 7.62 NATO bullet caused more damage than the 5.56 mm M-16 bullet.

Bellamy (27) recently reviewed the information collected on approximately 1400 gunshot wound casualties by the Wound Data and Munitions Effectiveness Team (WDMET) in Vietnam. Wounds caused by the M-16 rifle comprised about one fourth of these cases and Bellamy states unequivocally that they did not cause more severe wounding than other small arms used in this conflict.

SCOPE OF THE MISINFORMATION

Five International Wound Ballistics Symposia have been sponsored by the Swedish research group. The proceedings of these symposia have been published, and many readers assume that the information is valid scientific literature, selected by peer review. It is not. Papers submitted to these symposia are accepted and published without critical review. The major emphasis appears to be on attracting participation and interest in the symposia; this has resulted in greatly increasing the volume of data with no regard for the quality of this data. Serious contradictions in this work have gone unaddressed, e.g., two papers by Swedish researchers concluded that the amount of nonviable tissue around a projectile wound increases with time (28,29). Three papers from other countries (30-32) reported contradictory findings.

The degree of exaggeration is well illustrated by recommendations given by Rybeck (33). He wrote that "...the clinical experience [is] that tissues which have been subjected to the formation of the temporary cavity after a high velocity missile will not survive.", and "...the temporary cavity, especially after missiles travelling at high velocities, is very large (30 times the diameter of the projectile)...". Using Rybeck's conclusion to calculate extent of the tissue excision recommended for the wound shown in Figure 4, for example (5.56 mm M-16 bullet diameter,

multiplied by 30), we find a diameter of 16.68 cm (over 6 inches). Compare this with the experience of King, cited above (16), that this type of wound "...usually healed if left alone." The reader can judge for himself which treatment recommendation appears to be the more reasonable.

Rather than striving for a rational synthesis, correcting and striving to replace flawed data with more valid work, those in control of the symposia have attempted to suppress contrary information. For example, the printed Proceedings of the 5th Symposium (they did not appear until 1988 although the symposium was held in 1985) omitted a panel discussion in which data very critical of Swedish research methods was presented. Additionally, the printed Proceedings contained none of the comments made from the floor on the papers presented (many of these comments were critical of methods, conclusions, etc.) (34).

CONCLUSION

Scientific work demands hard choices, separating the valid from the unsound, the significant from the trivial, and the common from the rare. When this is not done the flawed works pile up, greatly outnumbering the valid; repetition compounds the problem and many are misled. The sad legacy of the misguided studies of the past twenty years can be found in the faulty understanding of wounding mechanisms and irrational treatment recommendations in recent surgical textbooks (35-38). The detrimental effects are clear. Most wounds seen on the battlefield are simple and have been treated by simple means with good results for the past one hundred years (5, 7-17). Since it has resulted in recommendations for unnecessarily radical explorations and excision of tissue for all "high-velocity" projectile wounds, and assumptions that all battlefield wounds fall into this category, the overall effect of the past twenty years of wound ballistics research can only be considered a giant step backwards. It is hoped that this documentation of the problem will stimulate corrective measures.

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- Fig. 1. All of the fragments that caused these entrance wounds remained in the body, as is the case almost without exception. This indicates that the striking velocity was probably not over 1000 ft/s (305 m/s).



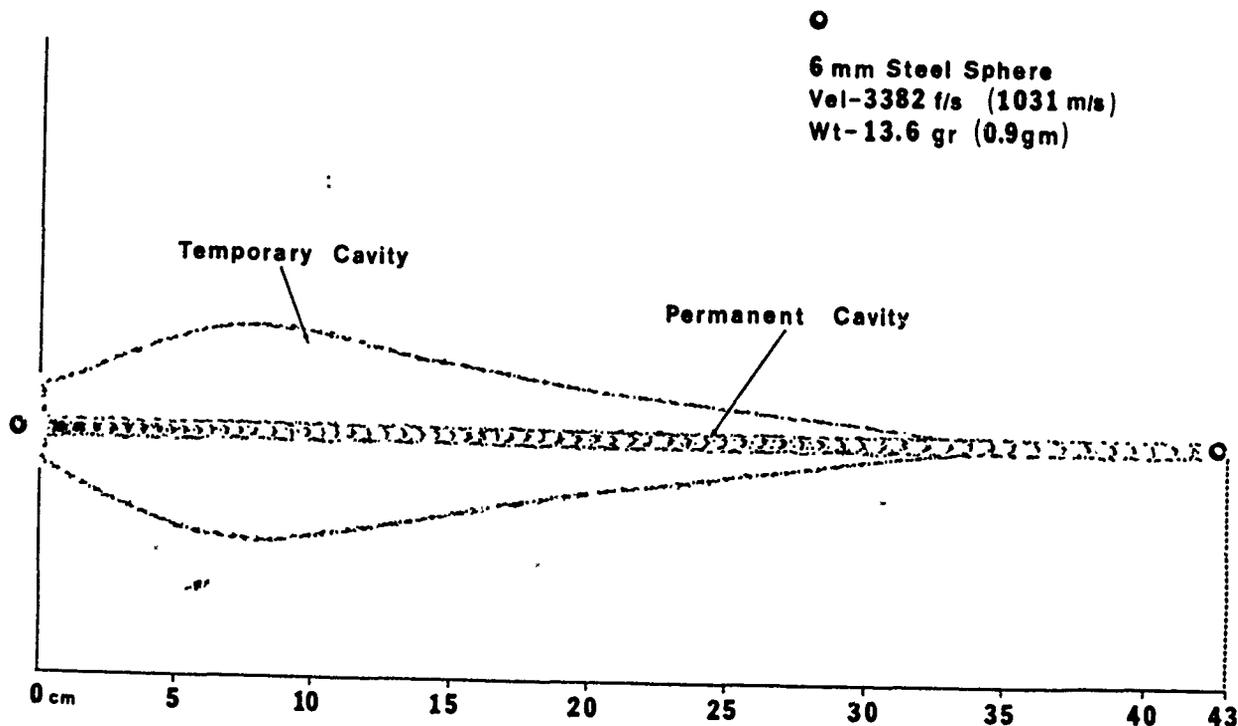


Fig. 2. Wound profile produced by a steel sphere. Observe that little or no cavitation occurs in the last 15 cm of penetration. This last part of the sphere's path corresponds to that observed in battlefield casualty, yet most wound ballistics researchers who use this projectile concentrate exclusively on the initial part of the path. The cavitation effects of the first part of the projectile path are not seen in fragment wounds of the wounded combat casualty and the cavitation effects produced by rifle bullets occur at a deeper penetration. Although the sphere does produce easily repeatable results, these results unfortunately do not reproduce battlefield type wounds.

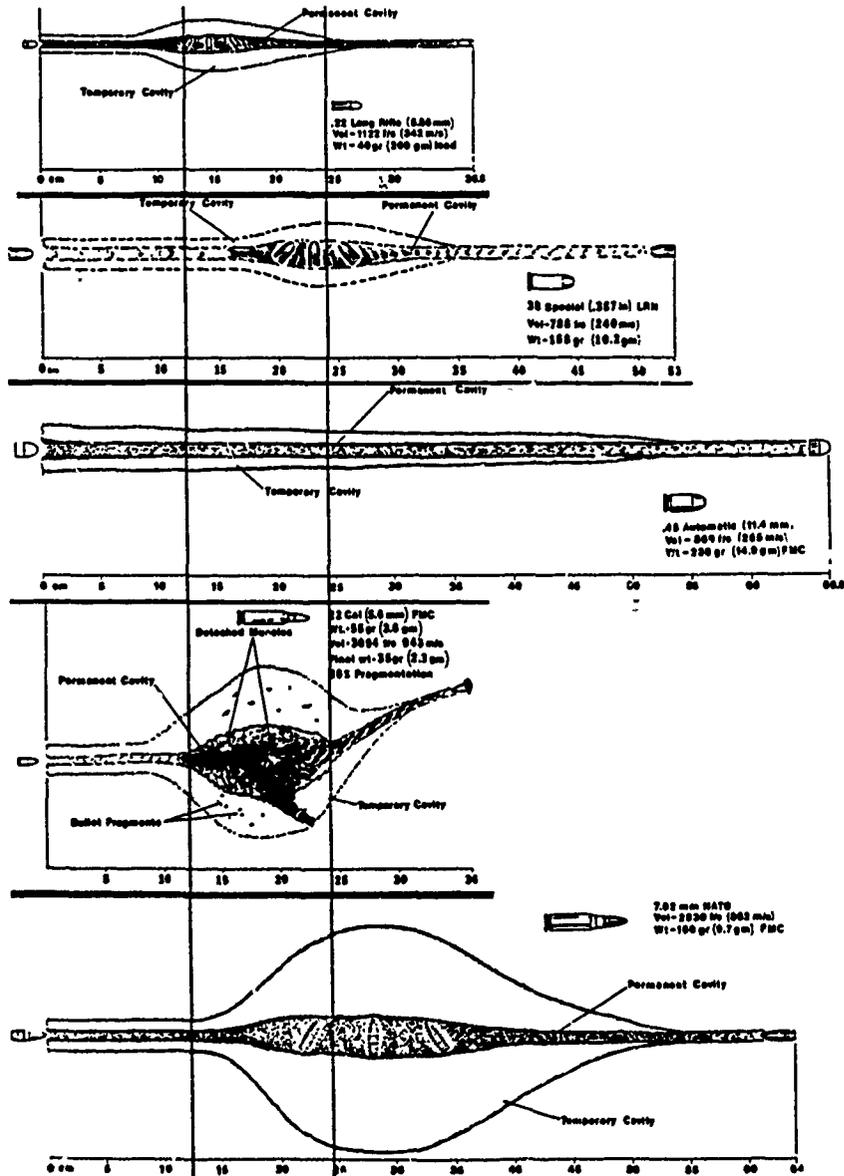


Fig. 3. Comparison of the first 12 cm of the projectile path in the five wound profiles pictured shows why the wounds from "high-velocity" rifle bullets may be no more disruptive than many simple extremity wounds caused by lowest velocity handgun bullet.



Fig. 4. This through and through wound of the plantar surface of the foot was caused by an M-16 rifle bullet. Despite the "high-velocity", tissue disruption was minimal.

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