

SUMMARY

The complexities of wound ballistics include not only the physical characteristics of the wounding projectile but also the biophysical characteristics of the target tissue. No single property of a projectile can explain all aspects of a wound. In the past, projectile velocity was considered to be the major determinant of a wound. Later ballisticians emphasized kinetic energy. Contemporary researchers view kinetic-energy transfer as the most important determinant of the nature of a wound. There is some truth in this contention, but even a theory of kinetic-energy transfer suffers from several limitations:

- All of the energy transferred by the projectile does not necessarily damage tissue. Projectile deformation or fragmentation requires energy, and a small portion of the energy appears as heat. The magnitude of the errors that arise from these energy-transfer mechanisms needs to be studied.
- The division of transferred energy into cutting and stretch is distinctly unequal. If Harvey's estimate is correct, one can show that very little of the energy transferred in the formation of a typical soft-tissue wound actually causes tissue damage. Even if Harvey's data substantially overestimate the amount of kinetic energy spent on temporary cavitation compared with the perma-

nent cavity, it is apparent that total energy transfer will apparently predict tissue damage poorly.

- There may be little relationship between energy transfer, muscle damage, and the resulting medical problem. In the rather benign wounds of entrance and exit caused by an M43 ball (Figures 4-49 and 4-50), tissue damage (as quantitated by the amount of muscle in the zones of extravasation and concussion requiring debridement) was small. Yet treating this wound required substantial effort—the permanent cavity included the femoral artery (Figure 4-51).

Any meaningful theory of wound ballistics must recognize that the interaction of multiple factors determines the nature of a wound. Although a projectile's wounding potential is determined by its mass and velocity, factors such as construction, stability, and the body part that is hit determine the extent to which that potential is realized."

Two combat casualties from the Vietnam War (Figures 4-52 through 4-55) may illustrate this fundamental insight. Both soldiers were struck in the forearm by bullets fired from AK47 assault rifles at ranges of about 20 m. The soldier shown in Figure 4-52 sustained a minor soft-tissue injury, while the soldier

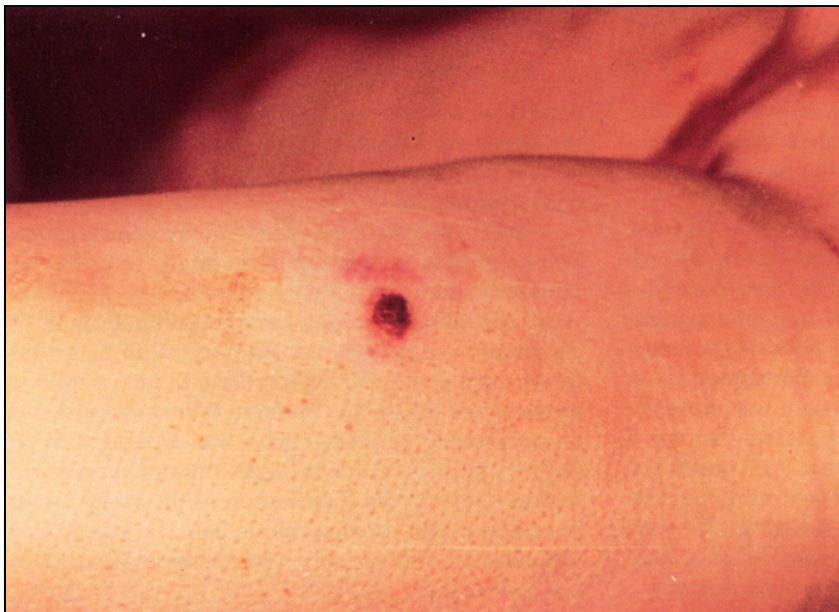


Fig. 4-49. This photograph, together with Figures 4-50 and 4-51, shows a casualty who sustained a perforating wound of the left thigh made by an M43 ball. This is the wound of entrance.

Source: Wound Data and Munitions Effectiveness Team



Fig. 4-50. The casualty's wound of exit. Neither this wound nor the wound of entrance shown in Figure 4-49 appears to be especially severe.

Source: Wound Data and Munitions Effectiveness Team

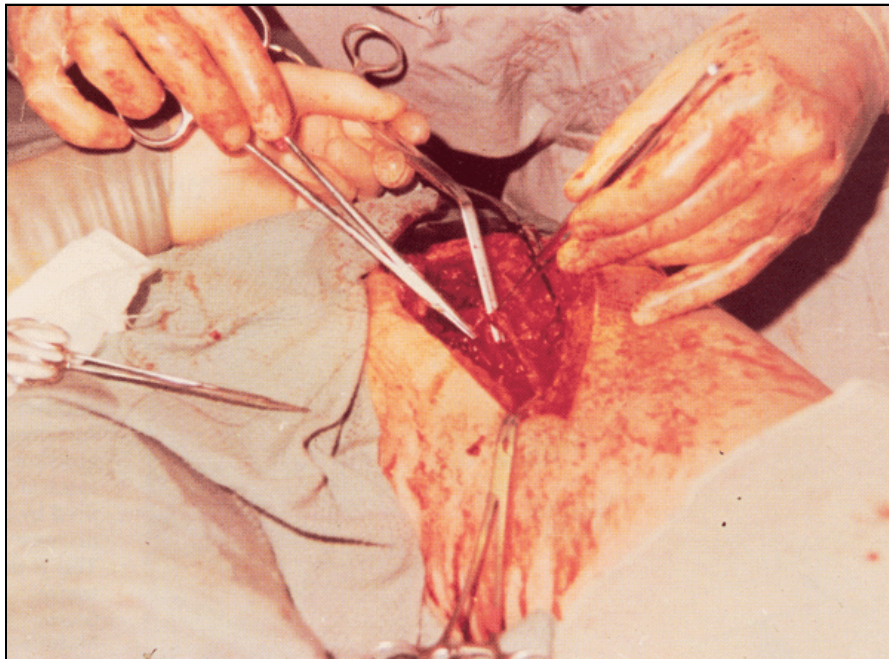


Fig. 4-51. Nevertheless, the casualty shown in Figures 4-49 and 4-50 had sustained a potentially fatal injury: The permanent cavity included the superficial femoral artery. There is little evidence of soft-tissue damage. In this case, as in many casualties, the apparent soft-tissue damage (and by implication, the energy transfer) did not correlate with the actual magnitude of the medical treatment problem.

Source: Wound Data and Munitions Effectiveness Team

shown in Figures 4-53 through 4-55 almost sustained a traumatic amputation of his arm. The bullets probably were of identical design and construction and had the same striking velocity and kinetic energy. In this instance, projectile velocity and kinetic energy clearly are not directly related to the magnitude of the wound. A meaningful theory of wound ballistics must explain such vast differences in tissue damage.

These two injuries are so different because, although the potentials for damage were identical, the full potential was realized only when the bullet hit bone. The gaping wound of exit testifies to the destruction wrought by multiple secondary projectiles arising

from bone and bullet, together with "explosive" temporary cavitation. The bullet that caused the injury in Figure 4-52 transferred a tiny fraction of its kinetic energy (perhaps less than 5%, or about 50 J), and all of that went into cutting a permanent cavity similar in size to the bullet itself. In contrast, the bullet that caused the wound shown in Figures 4-53 through 4-55 transferred most if not all of its kinetic energy (about 1,600 J) and made a truly explosive wound.

The key question that medical officers attempting to understand wound-ballistics theory must ask is not: *How much* kinetic energy was transferred? but rather: *What caused* the energy-transfer to occur?

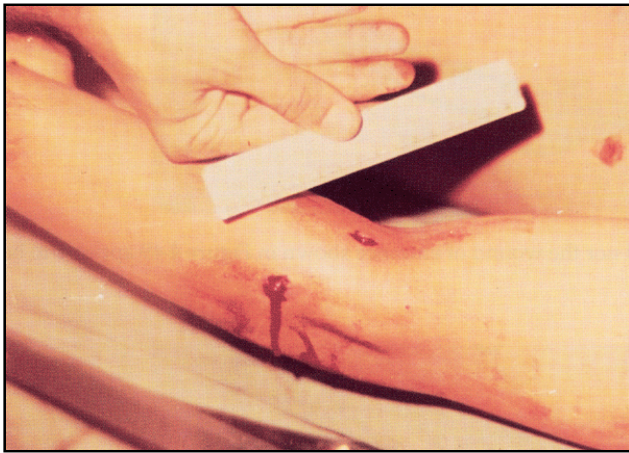


Fig. 4-52. This casualty sustained a perforating gunshot wound of the soft tissues of the forearm made by a bullet fired by an AK47 from a distance of about 20 m. The wounds of entrance and exit are small and approximately the diameter of the bullet. There is no evidence of bleeding and no ecchymosis or swelling. A similar wound could have been made by simply boring a hole through the tissue with a drill or trocar. This is an example of an en seton wound.

Source: Wound Data and Munitions Effectiveness Team

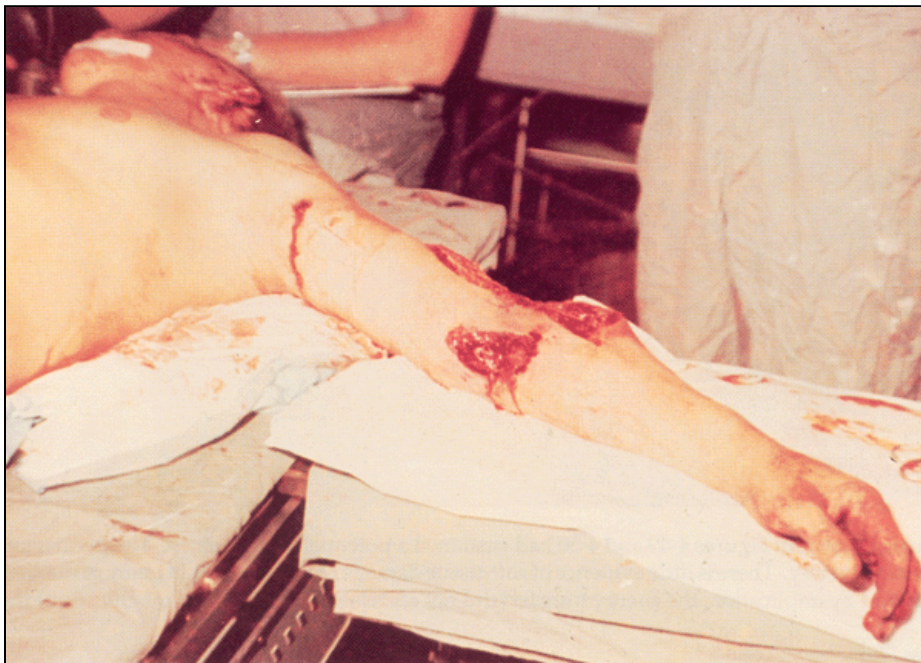


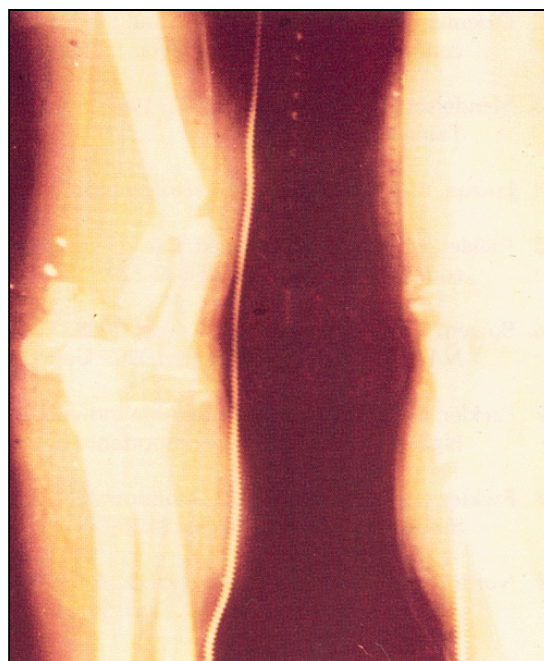
Fig. 4-53. This photograph, together with Figures 4-54 and 4-55, shows another casualty who sustained a perforating gunshot wound of the forearm made by a bullet fired by an AK47 from a distance of about 20 m. This is the wound of entrance.

Source: Wound Data and Munitions Effectiveness Team



Fig. 4-54. This is the wound of exit sustained by the casualty whose wound of entrance is shown in Figure 4-53.
Source: Wound Data and Munitions Effectiveness Team

Fig. 4-55. The shattered elbow shown in this roentgenogram nearly caused a traumatic amputation of the casualty's arm, in contrast to the benign nature of the wound shown in Figure 4-52. Since the circumstances of wounding were nearly identical in the two casualties, the difference in outcome cannot be explained by theories of striking velocity and energy. In the second casualty, the bullet hit and shattered the bones of the elbow as it passed through the arm. No drill or trocar could make a wound like this. The wound looks as if it had been caused by an explosion, and it is obvious that massive energy transfer must have occurred.
Source: Wound Data and Munitions Effectiveness Team



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RECOMMENDED READING

Janzon, Bo. 1983. *High energy missile trauma: A study of the mechanisms of wounding of muscle tissue*. Göteborg, Sweden: University of Göteborg. Doctoral dissertation. This academic thesis (108 pages) is a good introduction to the field of wound ballistics and the mechanisms of gunshot trauma. While it does contain extensive experimental data, it was written to be understood by people without advanced degrees in physics or mathematics. The book may be ordered from its author, Dr. Bo Janzon, Harbrovagen 34, S-147 51 Tumba, Sweden, or from the authors of this chapter.