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Comparison of Gunshot Wounds and Field-Tipped Arrow Wounds Using Morphologic Criteria and Chemical Spot Tests

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ABSTRACT: Arrow wounds represent an unusual class of wounds rarely seen by most death investigators. Although the edged, broadhead-tipped arrow produces a wound usually characteristic of archery/crossbow weapons, the plain, field-tipped arrow wound can be confused with gunshot injuries in those cases in which powder residue or firearm projectiles or fragments or both are not recovered.

We present a case of a deer carcass with a wound of uncertain firearm or archery origin which initiated a comparison of firearm wounds and archery wounds on fresh road-killed deer. We found the following features to be valuable in the differentiation of gunshot wounds and field-tipped archery wounds: First, the majority of the gunshot wounds (but none of the arrow wounds) had identifiable, macroscopic, wipe-off material and chemically identifiable wipe-off residue by spot test. Second, the archery wound defects had very inconspicuous abrasion rings as compared to the often prominent abrasion rings of gunshot wounds. Third, the actual central defect in the archery wounds was more likely to be oblong or slit-like compared to the gunshot wound defects, which were more likely to be round.

KEYWORDS: pathology and biology, archery, wound ballistics, arrow wounds, gunshot wounds, bullet holes, spot tests

Archery-related fatalities are uncommon and rarely reported. Only one reference was found pertaining to arrow injuries in a computer-assisted review of the contemporary literature [*1*]. Archery wounds do not have a separate *(ICD-9)* category to allow for statistical analysis of frequency from death certificate data. An informal telephone survey of several large medical examiner/coroner jurisdictions revealed only an occasional anecdotal reference to arrow wounds but very little experience with this type of injury. Fatal arrow wounds probably are infrequent due to the easy availability of much more powerful firearms in the United States, the cumbersome nature of the bow and arrow, and the close ranges needed in hunting situations before animals are fired upon, thereby allowing for good target recognition.

As the following case illustrates, there are circumstances in which knowledge of arrow-wounding characteristics is necessary to differentiate arrow wounds from gunshot wounds.

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Arrow wounds produced by edged, broadhead tips used for large game hunting purposes usually produce characteristic wounds reflecting the geometry of the tip (Fig. 1). These wounds are usually easily recognized as produced by arrows. Field-tipped arrows (Fig. 2) with rounded, pointed, or flattened tips used for target shooting and hunting of small game would be expected to produce entrance wounds more similar to those produced by firearm projectiles. A review of the English literature, however, failed to reveal any report systematically addressing the characteristics of arrow wounds with one exception [2]. In 1862, Dr. J. H. Bill outlined his experience with arrow wounds inflicted during the Indian wars in the western United States at that time. In addressing the characteristics of arrow entrance wounds, Dr. Bill stated that, "It is almost impossible to say whether the slit (the entrance wound) was made by a pistol ball or an arrow, so closely does the entrance wound made by an arrow resemble that made by a small ball" [2].

In an effort to derive differentiating characteristics between arrow and gunshot entrance wounds, we conducted the following study. We also evaluated the usefulness of chemical spot tests to detect lead and copper residue as an aid in identifying firearm from arrow injuries.

Case Report and Method

While making his usual weekly rounds of a local rendering plant, a South Dakota Game, Fish, and Parks officer noted a tagged deerhide with attached neck and head. Present in the lower neck was a large gaping, circular entrance wound (Fig. 3) which to the officer did not

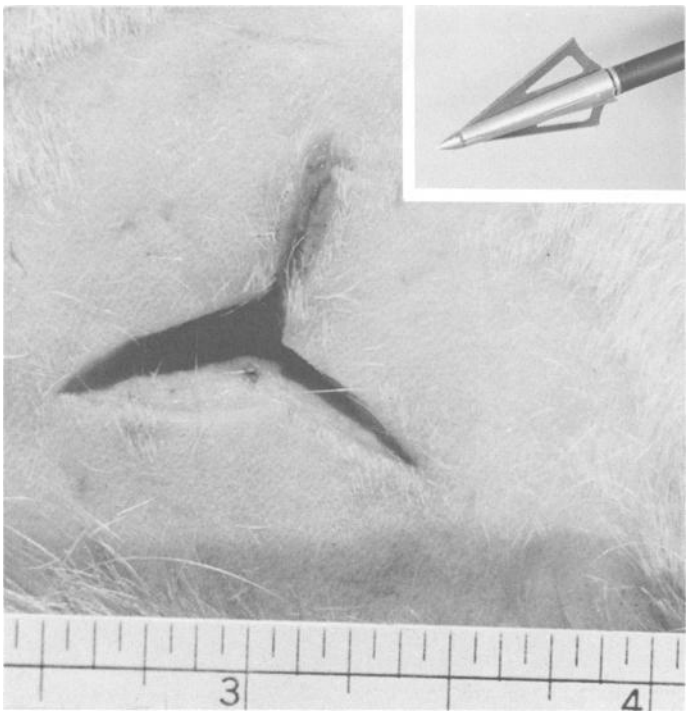

FIG. 1—*Arrow wound produced by three bladed broadhead-tipped arrow* (inset).

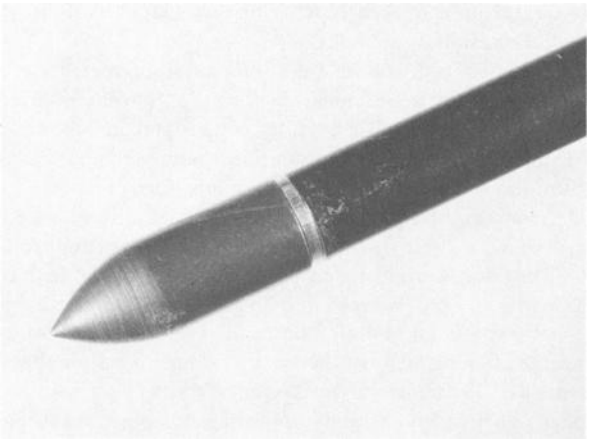

FIG. 2—*Field-tipped arrow.*

FIG. 3—*Shaved entrance wound from confiscated deer carcass.*

appear consistent with a wound produced by a broadhead-tipped arrow. Since the deer had been taken during archery-only season (requiring the use of broadhead tips), the hunter was questioned and stated that he had shot the deer with a field-tipped arrow. The officer had reason to believe that the deer had been shot with a 12- or 20-gauge shotgun slug. We were asked to examine the wound and determine whether it was characteristic of a shotgun slug or could have resulted from a field-tipped arrow.

The bone and most of the soft tissue beneath the wound were absent. An apparent exit wound was present on the opposite side of the specimen. Radiographic examination of adjacent soft tissue did reveal small flecks of metallic material, which on subsequent examina-

tion proved to be steel from a broken butchering saw blade. Tests for powder residue or firearm-related metallic residue were not done.

For comparison purposes, test wounds were inflicted upon recently road-killed deer carcasses and fresh beef hides from a local meat-packing plant. Weapons used included 12- and 20-gauge shotgun slugs, handguns firing fully copper-jacketed 9-mm ammunition, and .38-caliber solid lead semi-wadcutter ammunition. Semi-jacketed .32-caliber Winchester Special rifle ammunition was also used. Arrow wounds were inflicted with field-tipped and broadhead-tipped arrows and bolts fired from a 55- and 125-lb (25- and 57-kg) pull compound bow and crossbow, respectively. All of the wounds were fired from a distance of approximately 10 ft (3 m) and were inflicted perpendicularly on both shaved and unshaved hide. A total of 15 arrow and bolt wounds and 25 gunshot wounds (5 in each category) were inflicted. The original experimental design had called for additional wounds in both major categories; however, the homogeneity of the wounds led us to believe that although sporadic variation may occur, we were observing the common traits of each wound type.

The target impact velocity of the various projectiles was obtained using an Ochler Model 33 Chronotac chronograph with velocities representing a five-shot average. Chemical spot tests for lead and copper projectile residue using sodium rhodizonate and rubeanic acid, respectively, were performed on each test wound using the method outlined by Steinberg et al. [3]. In addition, swabs introduced directly into the wounds were also tested for lead and copper residue using the same spot chemical technique.

Results

Photographs of representative wounds from arrows and firearms are shown in Figs. 4 to 6. The arrow wounds had absent or inconspicuous abrasion rings, slit-like central defects, and no demonstrable wipe-off residue. The gunshot wounds, in contrast, had prominent abrasion rings, round central defects, and conspicuous wipe-off residue. The morphologic features of the 12-gauge rifled slug wound (Fig. 5) closely match those of the entrance wound of the confiscated deer carcass (Fig. 3). The target projectile velocities are shown in Table 1. Results of the chemical spots tests for lead and copper are shown in Table 2. Figures 7 and 8 illustrate positive chemical reactions for lead.

Discussion

If we judge from anecdotal experience, archery injuries are infrequent, and we would suspect that the potential confusion between archery and firearm injuries would be even more infrequent for most forensic pathologists. As seen in Fig. 1, arrows fitted with broadhead

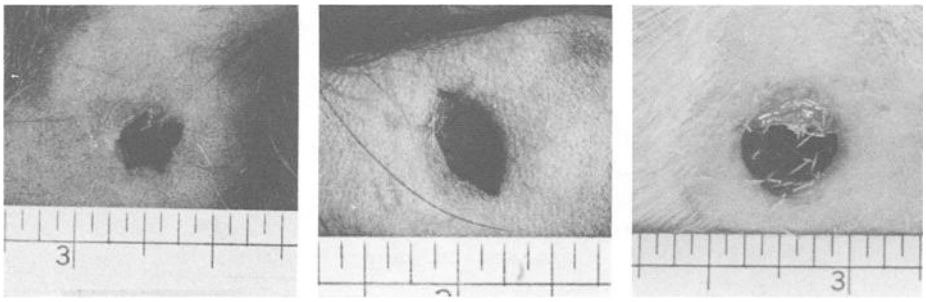

FIG. 4—*Three different test arrow wounds* (shaved). *Note absence of an abrasion ring, an irregular slit-like central defect, and absent wipe-off residue.*

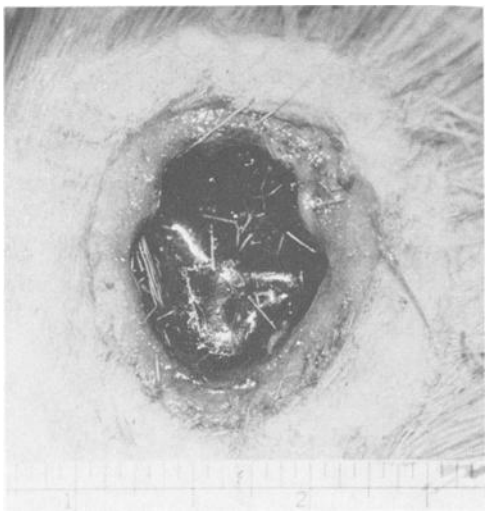

FIG. 5—*Shaved test entrance wound, 12-gauge rifled slug. This wound closely resembles entrance wound seen on confiscated deer carcass (Fig. 3).*

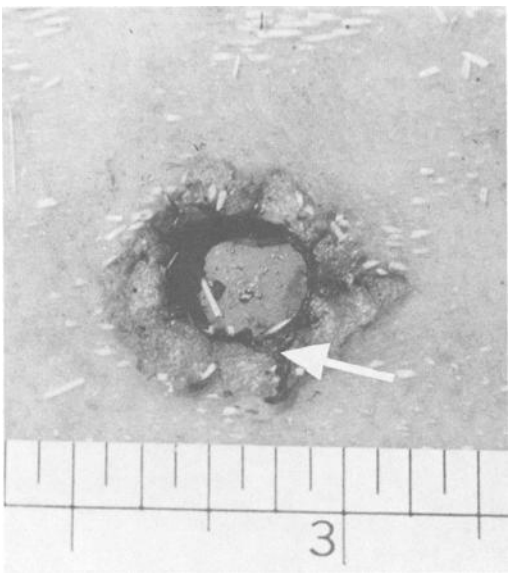

FIG. 6—*Shaved test entrance wound, .38 semi-wadcutter. Note circular central defect, prominent abrasion ring, and wipe-off material* (arrow).

tips (as most commonly used for large game-hunting purposes) leave a highly distinctive entrance wound which should leave little confusion with a non-contact gunshot wound once the wound is cleansed and closely examined. Other circumstances in which an arrow was found at the scene or an entrance wound only was present without an identifiable projectile recovered would also suggest an arrow rather than a firearm. Likewise, the recovery of a

TABLE 1—*Projectile velocities.*

Projectile	Velocity (ft/s)[a]
.32 Winchester Special	2280
20-gauge slug	1565
12-gauge slug	1530
9 mm	1085
.38 caliber	910
Crossbow bolt	240
Arrow	160[b]

[a]1 ft/s = 0.3048 m/s.
[b]Nonmeasured data, estimated velocity from manufacturer's data.

TABLE 2—*Lead and copper chemical test results.*

Weapon	Lead (*N* positive/total *N*)	Copper (*N* positive/total *N*)
Arrows and bolts	0/15	0/15
9 mm[a]	3/5	2/5
.38 caliber[b]	5/5	0/5
.32 Winchester Special[c]	0/5	0/5
12-gauge slug[b]	5/5	0/5
20-gauge slug[b]	5/5	0/5

[a]Full copper-jacketed bullet.
[b]Unjacketed solid lead projectile.
[c]Semijacketed bullet.

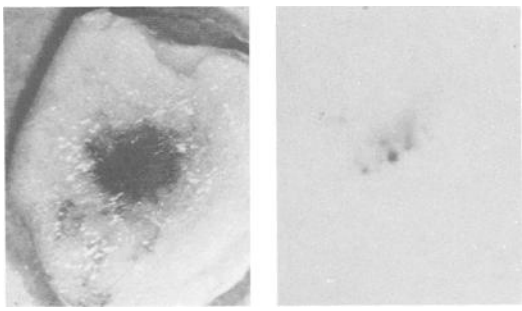

FIG. 7—*9-mm gunshot wound* (left) *with positive lead rhodizonate reaction* (right).

firearm projectile, obvious powder residue, or internal injuries indicative of a very high velocity/energetic projectile would indicate the use of a firearm.

Occasionally, however, as illustrated in the current case report, there may be a need to differentiate arrow from gunshot wounds when either could be likely. Our study did illustrate that field-tipped arrows and gunshot wounds share many characteristics and in many instances could not be differentiated absolutely from their entrance wound features alone.

FIG. 8—*Positive rhodizonate reaction for lead with control swab on the right. Positive swab from .38 semi-wadcutter solid lead bullet wound.*

We did observe some distinguishing features between arrow and gunshot entrance wounds, although these are by no means absolutely differentiating and are based on very small sample size:

1. Gunshot entrance wounds usually have a circular central defect, whereas arrow wounds were more likely to be slit-like or elliptical (Fig. 4). We are unsure what effect, if any, was produced on the arrow entrance wound during the withdrawal of the arrow.
2. Gunshot entrance wounds usually had prominent abrasion rings, particularly with larger diameter projectiles (Figs. 3, 5, and 6). Arrow wounds on the other hand had little if any identifiable abrasion ring (Fig. 4). Although projectile diameter appears to play a significant role in abrasion ring prominence, we also feel that projectile velocity is a significant factor. The arrows and bolts used in this study had significantly slower velocities than the firearm projectiles (Table 1).
3. On dry, cleaned, gunshot wounds, wipe-off material could be identified macroscopically in most of the wounds (Fig. 6). As shown in Table 2, most (but not all) of the gunshot wounds had demonstrable lead deposits identified by chemical spot tests (Figs. 7 and 8). Fully or partially jacketed bullets produced only occasional wounds positive for copper or lead. The chemical spot tests were all negative from the arrow and bolt wounds.

The nearly identical characteristics of the wound from the confiscated carcass (Fig. 3) and the 12-gauge slug test wounds (Fig. 5) and the dissimilarity to field-tipped archery wounds (Fig. 4) led us to conclude that the deer in question had been shot with a 12-gauge slug. The hunter ultimately was convicted of illegally shooting the animal with a firearm.

When the examiner is faced with differentiating arrow from gunshot wounds, we feel that the first order of distinguishing characteristics are the circumstances surrounding the wounding, presence of obvious powder residue, recovery of specific projectiles, internal wound features characteristics of high velocity firearm projectiles, and chemical or other physical evidence of powder/projectile residue on or in the wound. The secondary features listed above in Points 1 and 2 may be helpful in suggesting an arrow or bolt versus a gunshot wound, but certainly would not be definitive in distinguishing between these two categories of projectiles. We also realize that the secondary characteristics we have described are based on a small number of wounds. Although we feel that they are indeed general characteristics, larger series of wounds might well be expected to produce potentially overlapping degrees of variable wounding characteristics.

The recovery of powder/projectile residue by chemical spot test does appear to be a simple yet specific and relatively sensitive method of differentiating archery from gunshot wounds, particularly when nonjacketed projectiles are used. Interestingly however the projectile from

the .32-caliber Winchester Special ammunition, a projectile of the type likely seen in hunting situations, was uniformly negative by spot testing for both lead and copper residue material.

No difference in either wounding morphology or chemical spot testing was seen between wounds inflicted on shaved or unshaved hide.

Acknowledgments

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References

[*1*] Fingleton, L. J., "Arrow Wounds to the Heart and Mediastinum," *British Journal of Surgery*, Vol. 74, Feb. 1987, pp. 126-128.

[*2*] Bill, J. H., "Notes on Arrow Wounds," *American Journal of the Medical Sciences*, Vol. 43, 1862, pp. 365-387.

[*3*] Steinberg, M., Leist, Y., and Tassa, M., "A New Field Kit for Bullet Hole Identification," *Journal of Forensic Sciences*, Vol. 29, No. 1, Jan. 1984, pp. 169-176.

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