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Handling and Interpretation of Crossbow Injuries

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ABSTRACT: The longbow and crossbow are infrequently encountered by the forensic pathologist. As these weapons become more popular for sport and hunting, more fatalities may be anticipated. Three crossbow deaths (two homicides and one suicide) are presented. Included is the first report of a multiple shot death. The design and physics of the crossbow are described. The proper preservation of evidence, as well as wound analysis and interpretation, in such deaths are detailed.

KEYWORDS: pathology and biology, crossbow, bow and arrow, homicide, suicide, archery

The bow and arrow date to the Paleolithic era [*1,2*] and this weapon was apparently independently developed throughout the world with the exception of Australia [*2,3*]. The crossbow, a derivative of the longbow and a predecessor of the rifle, [*4*] originated around 400 B.C. [*5*]. It enjoyed its greatest popularity in the Middle Ages when it revolutionized modern warfare [*5*]. The rifle was much easier to use and slowly replaced the crossbow [*2,6*]. The longbow and crossbow are now becoming increasingly popular, primarily for hunting [*2,3,7*]. For an excellent synopsis of the history, development, and features of the crossbow, the reader is referred to the review written by Foley et al. [*5*].

Arrow wounds are not seen frequently in forensic practice and reports are usually anecdotal. Only a handful of cases have been described; these include suicides (and attempts), accidents, and homicides [*7–12*]. The two common types of arrowheads, field tip and broadhead, produce characteristic wounds [*7–9*].

Three crossbow deaths are described herein. The proper handling of evidence and wound interpretation are discussed.

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Case Reports

Case #1

In the early morning hours of Valentine's Day, a newly divorced man broke into his ex-wife's home through the basement window. Finding her still at work, he hid in her bedroom closet and waited for her to return. She appeared shortly thereafter with her new boyfriend who waited downstairs for her while she went upstairs to change. When the ex-wife opened the closet door the assailant grabbed her, threatened her with a knife, and superficially cut her throat. Downstairs, the boyfriend heard the scuffle and ran for help. The ex-husband stated that he was going to kill the woman, the boyfriend, and himself. She ran to the window and said that police were coming. At this time, she reported hearing a clicking sound. She turned to see her ex-husband holding a crossbow with a bolt (arrow) protruding from his head. When police arrived at the scene, the ex-husband was handcuffed as he was pulling on the bolt and stating that he wanted to be left alone to die. He was transported to a local hospital and died approximately 2 hours later in the emergency room. The projectile was left in situ pending autopsy.

The body was received with the bolt still in place (Fig. 1). It entered the right upper eyelid and penetrated the right orbital plate, right frontal lobe, tip of the right temporal

FIG. 1—*Entrance wound from suicidal crossbow wound to the right orbital area (Case #1). The subjacent orbital plate was extensively fractured.*

lobe, passed through the right lateral ventricle, trigone, and occipital lobe. The projectile exited the right posterior cranial fossa and right occipital scalp. The tip of the bolt protruded 1.5 cm. (0.6 inch) from the surrounding scalp. The arrowhead had three propellorlike, razor sharp blades. The entrance wound had a similar pattern of three radiating incisions with a shattered underlying orbital plate. The outwardly bevelled skull exit wound had three radiating linear fracture lines (Fig. 2). The right cerebral hemisphere was covered by diffuse subarachnoid hemorrhage. Cerebral edema was present with secondary uncal and cerebellar tonsillar herniation. Cortical contusions were noted along the wound tract.

The shaft was partially embedded within the orbital bone and the broadhead was unscrewed from the shaft and removed so as not to further damage the bone. The involved area of skull was resected and retained for possible further analysis.

A Thunderbolt-2 crossbow manufactured by Barnett International, Inc. was the weapon used (Fig. 3). It had a rated draw weight of 68 kg (150 pounds) and a rated bolt velocity of 84.4 meters per second (277 feet per second). It has a maximum effective range of 54.9 meters (180 feet) and produces 85 joules of energy (85 foot pounds) [*13*].

Case #2

The decedent, a 27-year-old black female, U.S. Navy Petty Officer was in her townhouse with her two small children, ages 9 months and 6 years. All were on the floor in the downstairs living room with the two children apparently sleeping in front of the television set, which was on. An open book and nearly full baby bottle were between the mother and the television.

At approximately 3 a.m., the local police department received an anonymous "911" phone call from a female who stated that there might be someone at the decedent's address who was in need of assistance. Police arrived several minutes later and found the front door of the residence locked. The officer proceeded to the rear of the dwelling and entered the unlocked door.

The decedent's body was prone on the floor with her head towards the television. Two crossbow bolts protruded from the back (Fig. 4). The unharmed children were immediately removed from the residence. The medical examiners arrived at approximately 4:45 a.m. The body had inapparent livor mortis and moderate rigor mortis in the extremities. The torso was warm; the extremities were cool. The hands and forearms were positioned underneath the thorax. The legs were crossed at the ankles with the left leg anterior. The bolts were left in place prior to autopsy.

The living room had several pieces of furniture overturned in the general vicinity of the body. A single, unframed painting, present near the feet, had four nondirectional blood spatters on the back. The remainder of the dwelling was undisturbed with the exception of the master bedroom where dresser drawers had been pulled out and overturned in the middle of the room.

During the course of the scene investigation, the decedent's estranged husband and his girlfriend appeared. He stated he had some money that he owed the decedent. At the scene, the husband's vehicle was examined and a crossbow case and a single bolt (not matching those in the decedent's back) were found in the car trunk. He subsequently confessed to shooting the decedent twice with a crossbow. He stated they became involved in a domestic argument and his loaded crossbow accidentally discharged striking the decedent once in the neck. According to the assailant, the decedent collapsed and began begging for him to end her life, as she was in unbearable pain. He then reloaded and fired, striking her in the back. He rejoined his girlfriend at a nearby nightclub. The girlfriend later admitted she had placed the phone call to "911."

At autopsy, two tripolar 2.8 cm (1.1 inch) gaping, incised wounds were identified.

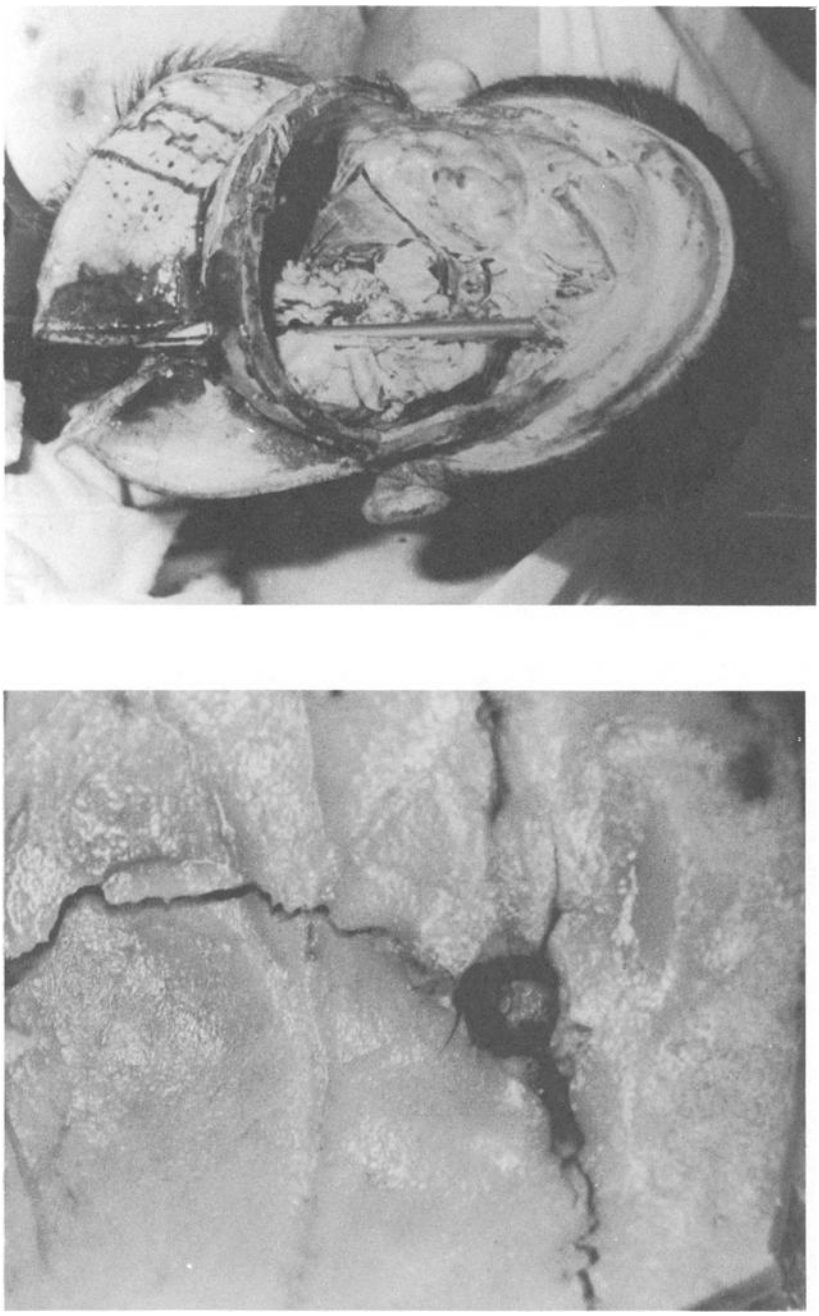

FIG. 2a—*Same wound as in Fig. 1 following removal of calvarium and cerebrum. Note the penetration of the bolt through the orbital skull with lack of complete perforation. This indicates that the projectile failed to achieve its maximal velocity and would be consistent with a contact or near-contact wound, as would be seen in a suicide;* (b) *Endocranial aspect (inner table of calvarium) of resected portion of skull from exit wound. Note the tripolar fracture lines indicating the bolt had a three-bladed broadhead. The defect is outwardly bevelled, confirming that the projectile entered on this surface. Such areas should be retained in order to perform toolmark analysis, if indicated (see text).*

FIG. 3—*Compound crossbow and bolt from Case #1.*

FIG. 4—*Scene photograph of Case #2. The decedent was prone with two crossbow bolts pro truding from her back. Her two children are visible next to the body.*

One to the left lower neck and one to the left back. Each had three roughly equal arms of 1.6 cm. (0.63 inch). An unlabeled gray metal 40.6 cm. (16.0 inch) long × 0.8 cm. (0.3 inch) diameter bolt with three red feather fletchings protruded from each wound. A three-bladed "Satellite" razor tipped hunting broadhead was screwed into the end of each (Fig. 5*a*). The blades were each 0.04 cm. (0.015 inch) thick. The broadhead had a maximal diameter of 2.4 cm. (0.95 inch). The neck wound penetrated between the 2nd and 3rd cervical vertebrae transecting the right side of the spinal cord. Minimal hemorrhage was evident grossly at this site. A portion of one blade of the broadhead was

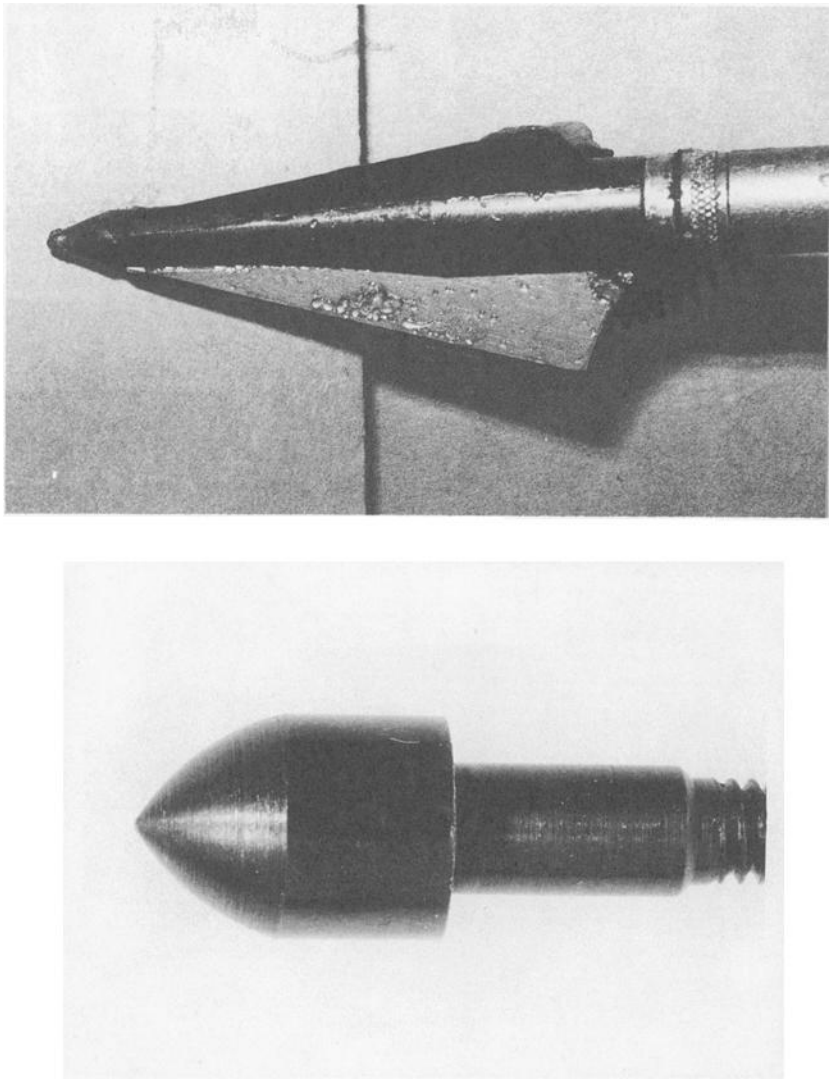

FIG. 5a—*Three-bladed hunting broadhead from Case #2. The tip is dulled slightly due to its perforating the body and striking the underlying floor. This would indicate the decedent was already prone when this injury was inflicted;* (b) *field tip arrowhead, which may produce injuries indistinguishable from gunshot wounds with perforation of the body.*

broken off and embedded within the cord (Figs. 6,7). This wound was directed anterior, superior, and medial.

The second wound was to the left back and entered the 9th intercostal space, perforating the left lower lung lobe and cardiac ventricles. It was directed superior, anterior, and medial. This bolt exited the 2nd intercostal space and apparently had impacted the underlying floor with subsequent blunting of the sharp tip. Thirteen hundred mL of liquid and clotted blood were in the left hemithorax and 100 mL within the pericardial sac.

Subsequently recovered was a Barnett crossbow, consistent with a Wildcat XL or Panzer II model with a tested 100–125 pound draw (rated draw 150 pounds). The bolt protector shield had been removed. The ends of the bow showed evidence of fiberglass strain (separation) consistent with the manual setting of the bow-string.

Case #3

The decedent, a 28-year-old unemployed and homeless male was found at 5 a.m. by a hotel security officer. The officer was responding to a report by a hotel employee of a man lying on the hotel's loading dock with an arrow protruding from his chest (Fig. 8). The deceased was found on the dock on top of a small rug and portion of cardboard box that he had been using for a bed. Hotel employees had last seen him alive about 4 hours earlier in the same spot, sleeping under a canvas tarpaulin.

The case remained a mystery for 15 months until the investigating detectives received a phone call from an 18-year-old woman who claimed to have knowledge of the murder. She stated that 2 months after the body of the victim had been found, she and her 18-year-old male friend had been using drugs with another couple when he stated that he

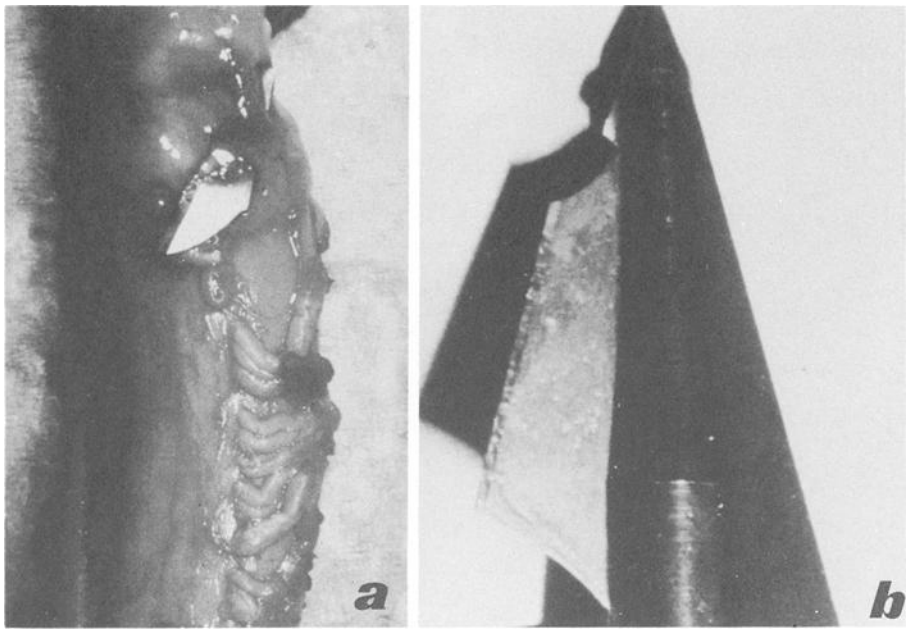

FIG. 6a—*Resected portion of cervical spinal cord from Case #2. The cord was partially transsected by the broadhead. Minimal hemorrhage surrounds this site consistent with this being the second of two fired shots;* (b) *broadhead corresponding to* (a). *The fragment of blade matched the missing portion observed, both geometrically and by toolmark analysis.*

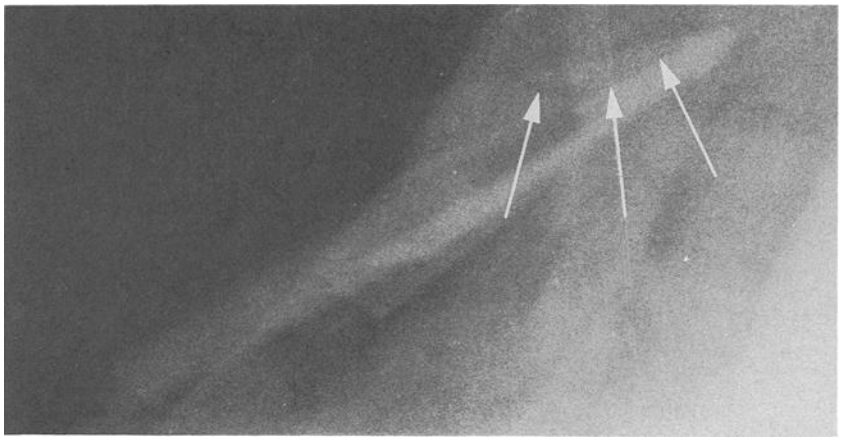

FIG. 7—*Lateral cervical spine radiograph (Case #2). Fragment of broken broadhead is noted by arrows.*

had killed a man with a crossbow. He said that he had been with another man driving in the area where the body was found. He took his crossbow to that area because he had grown bored with shooting targets that did not move and knew that homeless people slept in the vicinity. The victim had been lying on his side and, when hit by the arrow, began to shake then rolled onto his back. The reason given by the assailant for the shooting was that "... it was the killer instinct, that every human has to go out and hunt." When confronted by detectives with this story the offender confessed and con-

FIG. 8—*Case #3. The bolt protruding from the body corresponds to the angle of trajectory for the projectile (see also Figs 4, 7, and 9).*

firmed the details of the incident. The weapon was described as a crossbow with a brown wood stock that had been purchased from a mail order house. It was never recovered.

The fully clothed body arrived for postmortem examination with a yellow metal 0.6 cm. (0.24 inch) diameter bolt with three red plastic fletchings protruding from the right chest. The bolt perforated the right thoracic wall between the 4th and 5th ribs to penetrate the right lung and heart (Fig. 9). The X-shaped gaping entrance wound in the right chest corresponded to the 4 bladed broadhead on the bolt (Fig. 10). The roughly equal arms of the wound were each 1.2 cm (0.47 inch). The course of the wound was from anterior to posterior, right to left, and slightly down. A 900 mL right hemothorax and a 150 mL hemopericardium were associated findings. The bolt came to rest within the heart and did not enter the left hemithorax or exit the body.

Discussion

The longbow or bow and arrow was in use over 100,000 years ago [*1,2*] and its use has been credited to Neanderthal tribes [*2*]. The impact of this invention has somewhat diminished with the passage of time, however, its historic import has been equated with that of fire, the wheel, and communicative speech [*2*]. Its major drawbacks are that its use requires skill and its range is somewhat limited. The bow remained the primary weapon employed for hunting and for military purposes from its inception into the Mid-

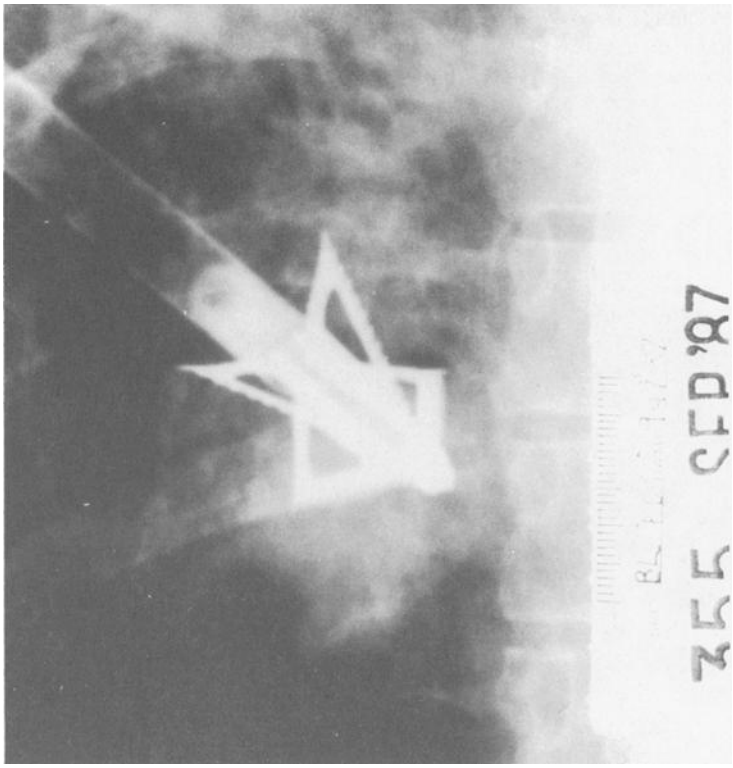

FIG. 9—*Radiograph of crossbow bolt in situ in Case #3. The projectiles should be left in place until such films are obtained.*

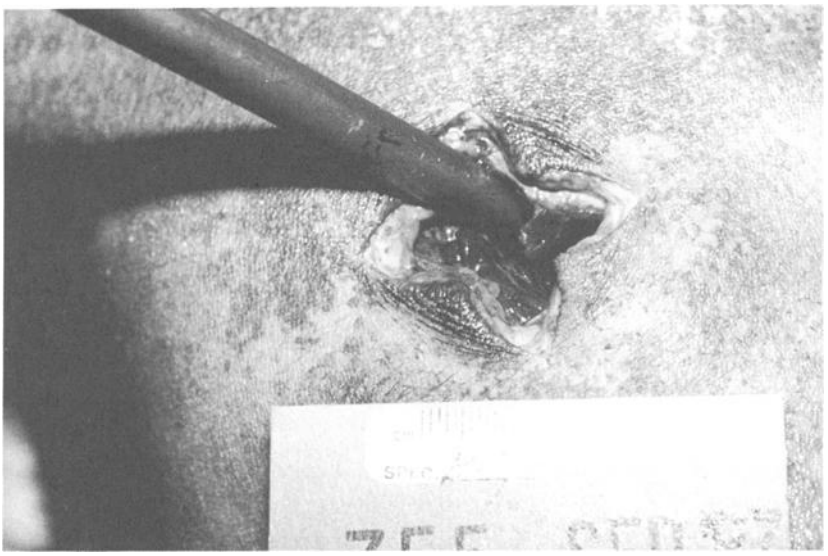

FIG. 10—*Entrance wound corresponding to Fig. 9 prior to removal of the bolt. The gaping wound should be reapproximated in order to ascertain its true nature.*

dle Ages [*1,3,5,6*] throughout the world, except in Australia where it apparently never was developed indigenously [*2,3*].

The crossbow, which may be viewed as a modern derivative of the longbow and rifle, [*4*] is actually an adaptation of the former and a forerunner of the latter. The crossbow first appeared approximately 400 B.C. and is credited to the Greek and Chinese [*5*]. It derived from ancient catapults that were designed to throw not only stones but also arrows [*6*]. The inventors made good use of their existing technology, employing sound mechanical principles and aerodynamics [*5*]. Several advantages of the crossbow over the longbow included: ease of operation, increased accuracy, increased power, fixed draw length, improved range, flat launch trajectory, and partially mechanized firing cycle [*4,5,7,14,15*]. For these reasons, particularly the abilities to pierce armor and be maintained in a loaded ready-to-fire position, and relative lack of skill required for use, the crossbow revolutionized modern warfare [*5*].

The greatest popularity of the crossbow was from the 11th through the 16th centuries when it was considered "the most accurate and deadly of all weapons" [*5*]. Over this period, its military use changed from a defensive weapon (used in protecting fortified positions) to an offensive one (used in close contact man-to-man confrontation and in mass discharge ahead of advancing warriors) [*6,15,16*]. The arablest, or continental crossbow, made use of metals to construct the bow allowing increased power but also required a mechanical aid to assist in drawing the bow string [*15,17*]. It fired war bolts or quarrels that had squared metal heads and which were able to pierce armor [*6,15*].

Though a marvel of "modern" weaponry, the crossbow was not universally applauded. In fact, it was considered by some "a cruel and barbarous weapon." In 1139, Pope Innocent III banned its use against Christian nations but allowed it to be employed against infidels. It was reintroduced by England's King Richard I, who in one of history's great episodes of *deus ex machina* was killed several years later by crossbow wound [*5*].

Gradually, both the longbow and crossbow were replaced by the rifle, which had the additional benefits of a fully mechanized firing cycle, greater range, and increased ac-

curacy [2,5,6]. Even into the late 18th century, however, the crossbow was the superior weapon in head-to-head competition [5]. As the military uses diminished, sport uses arose such that the modern crossbow aficionado employs it primarily for hunting [2,3] although its use is banned or restricted in several states [4,11,17]. The hunt is reportedly made more challenging by the limited range and slow rate of repeated firing, but is aided by the rapid speed of single shot fire, quietness of operation, and minimal skill required for its use [2,4,7]. Crossbows may be legally obtained in many states through gun or archery shops. In addition, one may be easily obtained via mail order without permit or background check [11].

The crossbow can be considered a midway point in the evolution of the rifle as its overall design indicates. From the bow it derives its mechanism and design for shooting power; from the rifle come the trigger and sites to aid aiming and firing. The weapon is held and fired as a rifle, usually from the shoulder but possibly from the hip. No international design standards exist; [14] however, the weapon consists of a wood bow or prodd (approximately 0.81 m or 31.8 inch) mounted perpendicularly to the approximately 0.91 m (35.8 inch) "tiller" or stock (Figs. 3,11) composed of wood, metal, synthetics, or composite [5,14]. Sights allow correction for windage [4]. The bowstring is perpendicular to the line of fire and is drawn either by hand or by lever. This string is held under tension in a string release slot until released by squeezing the trigger. The ends of the prodd may be recurved to achieve greater thrust [3]. The "arrow" (bolt) is loaded once the bowstring is properly positioned. It consists of a metallic, wood, fiberglass, or composite cylinder with "feathered" fletchings about the periphery of its flat base or butt (Fig. 12). The purpose of the fletchings is flight stabilization by preventing rotation [5]. The stock has a longitudinal groove on its superior surface which acts as a guide for the bolt to ensure a straight shot. Several variant crossbow designs have included a Cingalese repeating crossbow [6]. Hand held pistol grip variants are in recent use [4].

The arrowhead can be one of many varieties: the most common are the field tip and the hunting broadhead. The field tip (Fig. 5*b*) is conical and usually metal. The broadhead

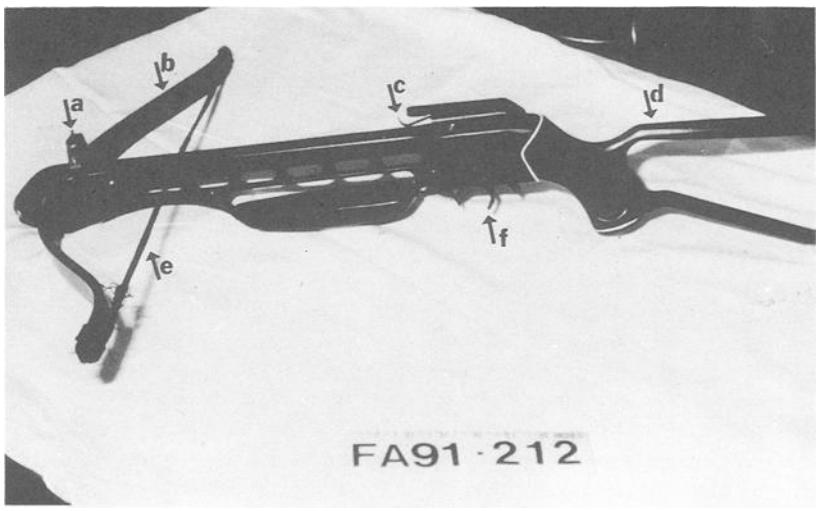

FIG. 11—*Crossbow recovered from assailant in Case #2.* (a) = *sight,* (b) = *bow (prodd),* (c) = *string release shot,* (d) = *stock (tiller),* (e) = *bowstring, and* (f) = *trigger. The ends of the bow showed evidence of fiberglass strain, consistent with manual setting of the bowstring.*

has multiple (2, 3, 4, 5, or possibly greater) replaceable razor sharp metal vanes attached to the tip (Figs. 5*a*,13).

The physics of archery is basically that of low velocity projectiles, with distant range longbow shots in particular simulating extreme range artillery ballistics [*18*]. The velocity of an arrow, bolt, or any low velocity projectile in flight is the vector sum of its actual horizontal and vertical components as defined by the products of each with the cosine and sine, respectively, of the launch angle [*18*]. The projectile is decelerated by drag (air resistance) as defined by the equation: $D = PAV^2K$ (where D = drag, P = air density, A = largest cross sectional area, V = velocity, and K = "form factor" constant influenced by the relative length and weight of the projectile). The projectile weight is also significant as: $a = Dg/w$ (where a = deceleration, D = drag, g = gravity, and w = weight). Other factors to be considered are the fletchings (which produce pronounced drag) and the projectile shaft length (turbulent air flow increases with increased shaft length) [*5*]. With a given weapon, specifically the crossbow's bolt where the draw length and launch angle are essentially constant, the most significant measurement is the aerodynamic drag: weight ratio with lower values suggesting probable greater range of fire [*5*].

A modern crossbow may have a maximal velocity of 61 m/s (200 ft/sec), with a range of 270 m (885 ft) and a draw weight of 68.1 kg (150 lbs) [*3,13,19*]. This contrasts with the ancient military arablest, which had a 550 kg (1210 lbs) draw and a 420 m (1377 ft) range [*5*]. The maximal velocity is attained as the bolt leaves the bowstring and decreases thereafter as it is affected by air resistance and gravity [*18*]. The maximal speed is possible only if the bolt has no resistance through its complete 40.6 to 60.8 cm (16 to 20 in) internal draw [*10,11*]. If the weapon is held at arm's length (as in a suicide), the bolt likely would strike the body prior to discharge from the bowstring and as a result would have decreased velocity and its penetration into the body would be reduced as occurred in Case #1.

The target affected is also of import as the bolt may not perforate weight bearing bones, but will pass through ribs and possibly axial bones [*9*]. This was evident in Case #2 and Case #3 where the bolts penetrated intercostal spaces. In Case #2, the body was perforated allowing the broadhead to impact the underlying floor, dulling its tip. In

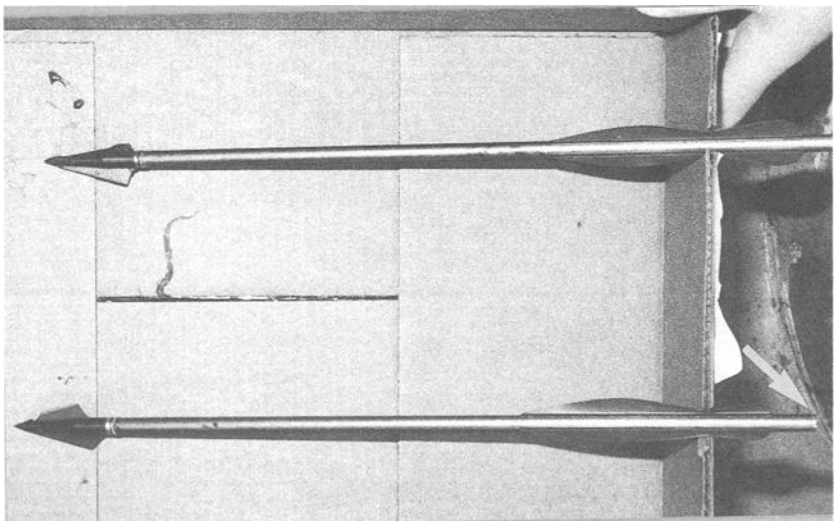

FIG. 12—*Two hunting broadhead equipped bolts (Case #2). The feathered fletchings are near the flat butt (arrow) of the projectiles.*

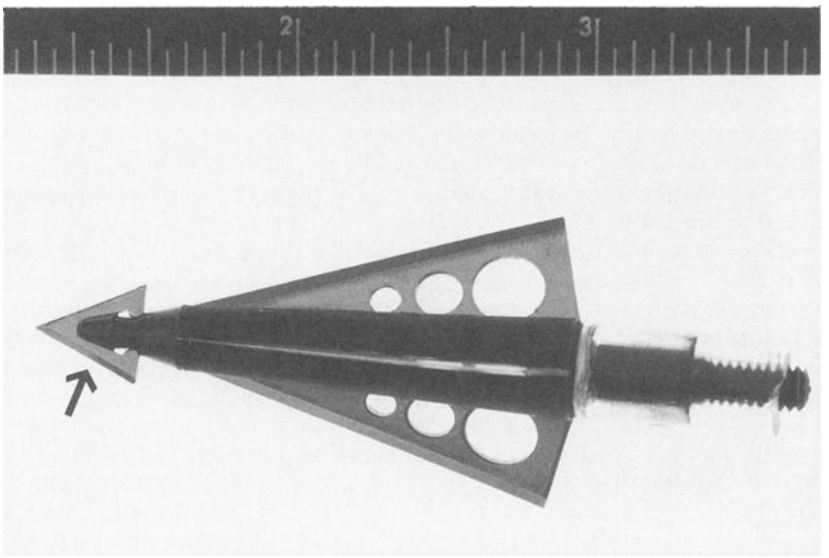

FIG. 13—*Three-bladed hunting broadhead equipped with small primary blade at the tip* (arrow) *which would initially penetrate the target.*

particular, the transorbital route offers very little hindrance to a sharp force penetrating weapon [*20*] as was apparent in Case #1. In this death, the bolt perforated the brain and the arrowhead partially exited the calvarium (Fig. 2*a*). This information may be beneficial in cases where the bolt completely perforates the body, particularly the skull, as a "footprint" of the general type of broadhead remains (Fig. 2*b*) [*9*]. Thus despite the absence of a projectile, the examiner may be able to ascertain its general nature. In such a case, one should excise the involved bone as it may indicate the weapon (arrow or bolt) and its overall configuration (broadhead versus field tip). It may also be possible to perform comparative tool mark analysis of the resected bone and a suspect weapon.

Should the bolt suddenly impact an extremely hard surface (stone, thick axial bone, etc.) it may shatter or deform the shaft [*18*] and/or the arrowhead, particularly the broadhead [*9*]. In event of the latter, the subsequent wounds inflicted by the projectile may be distorted by the aberrant arrowhead geometry, thus the exit wound may not be identical to the entrance [*9*]. This occurred in Case #2 where the bolt impacted the 3rd cervical vertebra and the broadhead fragmented with a portion lodging within the upper spinal cord (Figs. 6*a* and 7). This would be particularly significant if the projectile had exited or been removed prior to autopsy. Not only might it be possible to physically match the overall geometry of this fragment to a recovered broadhead (Fig. 6*b*), but tool mark analysis may substantiate these similarities as occurred in Case #2. Also of note, these portions of razor sharp material may present an unexpected hazard for the prosecutor [*9*].

A medical examiner usually encounters an anecdotal account of bow injuries. This may be due to the lack of a codable diagnosis, much greater prevalence of firearms, relatively large size of bows, and close range required for effective use of bows [*8*]. A recent study of hunting injuries noted 24% of 104 patients were admitted for sharp force (knife or arrow) penetrating wounds, [*21*] presumably with arrow wounds in the vast minority given the relative infrequency of these weapons compared with hunting knives. Suicides (attempts [*10,11*] and successful [*9*]), homicides [*7*], and accidental [*12*] deaths have been described with crossbows and more deaths may be predicted as the weapon

increases in popularity [5] and as the population increases [9]. Another avenue through which the medical examiner may come into contact with bow injuries is in animal deaths of questionable legality, such as a domestic animal shot "for sport" or game taken out of season for the weapon involved [22–24]. Cases wherein an animal was killed with a rifle or shotgun and impaled postmortem to conceal the criminal act have also been described [24].

The mechanism of an arrow injury is usually obvious if the projectile protrudes from the wound, [7,8] however, one must bear in mind the possibility of insertion into a preexisting gunshot wound [24]. Radiographs should be obtained to rule out this possibility and to localize any projectile(s) and/or fragment(s) present. These studies may have been obtained by treating physicians if the patient survived to the hospital as plain radiographs, computed tomography, and selective angiography are indicated in such cases, particularly to assess vascular injuries [12,25].

The two major types of arrowheads, field tip and broadhead, produce distinctive wounds. Both are characterized by outwardly bevelled entrances and exits in involved bone. The conical field tip produces a circular to ovoid slitlike skin defect that may resemble an entrance gunshot wound [8,9]. The arrow wound may have a circumferential marginal abrasion that may be as prominent as that in a gunshot wound [9]. The exit wound may mimic that of a gunshot wound as the skin is pierced from the internal aspect and lacks an abrasion unless the involved area is shored [9]. Distinction between gunshot and arrow wounds might pose a problem if the arrow or bolt had been removed by the assailant or if it had perforated the body [8,9]. These injuries may be chemically distinguished by tests for lead and/or copper that may be positive with unjacketed bullets but negative with arrows [8]. A low velocity field tip wound usually lacks the cavitation of some gunshot wounds, a fact that may also be helpful in distinguishing the two [9].

The broadhead is used primarily for hunting and generally has between two and five razor-edged metal blades radiating outward from a central shaft [7,9] with a conical tip or small primary blade which initially penetrates the skin (Figs. 5,13). The array of metal vanes produces a characteristic entrance defect which corresponds to the arrowhead's geometry (Figs. 1,14) [7,9]. Such wounds should be reapproximated to reveal their nature. The comparative "fit" may be assessed as the latter is being withdrawn (Fig. 15). The blades produce radiating incised wounds that lack abraded edges, both on entrance and on exit [7,9]. In addition, the array of incisions produces a large diameter gaping wound (Fig. 16) along the entire course [9] and as such a great deal of associated hemorrhage would be expected. The center of the entrance wound may have a slight irregularity of the arms of the incision(s) [7], which presumably is due to stretching of the skin as the primary blade or tip contacts and enters. The following blades then strike a somewhat stretched epidermis and pass cleanly through. Graze broadhead wounds may produce serpentine or polygonal skin injuries [7]. Both the tip and blades produce outward bevelling of bone. The latter may result in minimal or prominent bevelling, depending on the bone involved.

The arrow or bolt itself may be one of the only clues to the identity of an unknown assailant. No clear protocol exists in handling wounds of this type, thus a proposed methodology includes: the arrow should be left in situ if possible when the body is transported to the autopsy facility and a paper bag should be placed over the protruding portion in order to preserve any evidence that may be present. Photographs should be obtained of the projectile(s) in situ. The feathered fletchings produce no markings if they enter the wound, however, they may carry trace evidence into the defect [7]. Removal of the arrow may compound any injuries present and in clinical patients may increase morbidity and mortality, thus it is recommended that they be left in place until the patient is examined.

The suggested technique for removal involves dissection to the general area of the

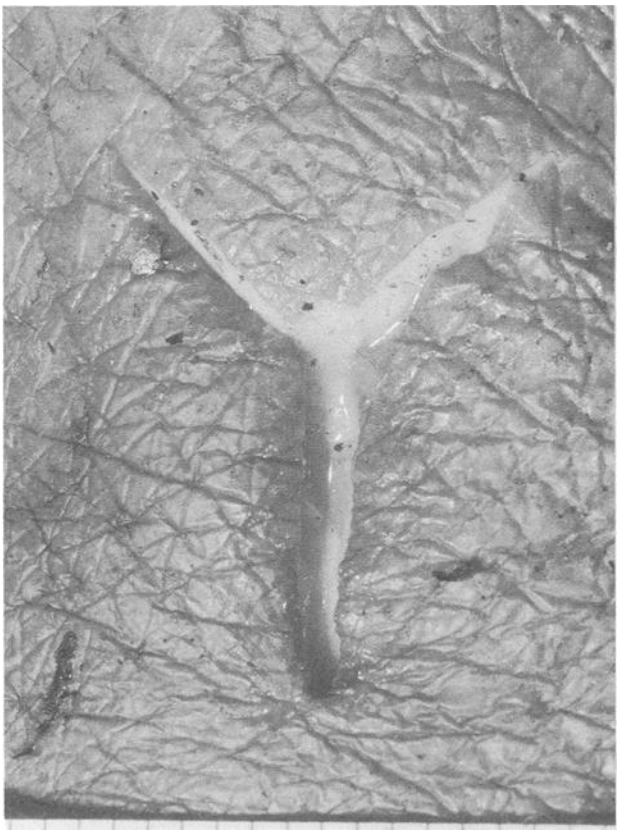

FIG. 14—*Reapproximation of wound from a three-bladed broadhead reveals the true nature of the wound (reconstruction of wound in Case #2).*

arrowhead and wound track followed by a single linear incision down one side of the shaft in order to free the arrowhead [*23*]. The arrow should be handled in such a way as to preserve any latent fingerprints that may be present [*23*]. As the arrow is withdrawn from the skin defect(s) photographs should be obtained to establish match of wound(s) and weapon(s). The projectile itself may help to establish ownership as serious archers may manufacture their own arrows and these may have distinct design features or fletchings [*23*]. Commercially available arrows offer minimal (if any) definitive evidence proving ownership. The relative rarity of these weapons may suggest suspect(s). Local archery and gun shops should be canvassed to establish if and to whom a weapon similar to that involved in a crime was sold. In Case #2, police investigators were able to track the credit card purchase of hunting broadheads by the assailant mere days prior to his attack.

Internal injuries should be assessed with attention to order of fire if multiple shots are involved. They should then be compared to the suspect(s)'s account(s) of how and in what order the wounds were inflicted. The long and rigid nature of these projectiles provides concrete evidence of shot trajectory and may localize the shooter relative to the victim [*26*]. In both Cases #2 and #3, the angle of the wound(s) were consistent with shots being fired from an erect assailant aiming downward toward a horizontal victim.

FIG. 15—*Bolt being withdrawn from the entrance wound to the chest in Case #2. The concordance of the wound and projectile may be important in cases where an arrow was inserted into a previously existing gunshot or shotgun wound.*

In Case #2, the tip of one of the broadheads was dulled and supported this opinion. The paucity of hemorrhage surrounding the transected spinal cord in Case #2 indicated this shot probably was fired last and while the victim was in extremis. This contrasted sharply with the attacker's initial account wherein he stated he fired the first shot to the erect victim's neck causing her to collapse in agony. If in fact this shot were first, the associated cord trauma would have been such that the victim wound have in all probability been unable to speak or unconscious. Copious hemorrhage from this large incised wound would be anticipated if the patient were normotensive. Subsequent information confirmed this opinion of the order in which the shots were fired. In Case #3, the direction of the shot from the decedent's right and downward was consistent with the statement that the decedent was laying on his left side when shot and subsequently dropping onto his back.

Summary

The longbow dates to prehistoric times and the crossbow to the early first millennium. Both were historically weapons of war but fell into disfavor with the introduction of the rifle. A resurgence in archery's popularity is attributed, in large part, to hunting enthusiasts. The crossbow may be considered a longbow-rifle hybrid and shares many design features of both. It fires arrows or bolts that behave as low velocity projectiles. The arrowhead may be one of two general designs—the column field tip or the hunting

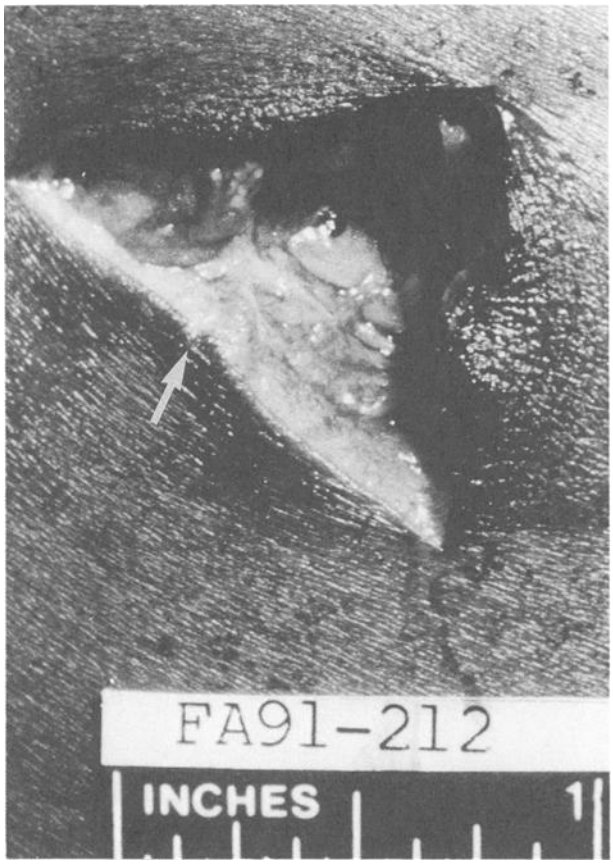

FIG. 16—*Gaping entrance wound corresponding to Fig. 15. Note the small skin defect near the center of the wound* (arrow) *as may be seen in such injuries.*

broadhead. The latter consists of multiple razor-edged vanes and produces a gaping incised wound. Both cause outwardly bevelled bone defects, as seen in gunshot wounds. The nature and analysis of crossbow wounds are important to understand as they may clarify the sequence of events in death by these weapons. Trace evidence may be carried by the feathered fletchings at the base of the arrow. Efforts should be taken to preserve any possible latent prints on the arrow. If possible, the projectile should be left in situ until the exact nature of the wound is determined by the forensic pathologist. Radiographs should be obtained to determine wound course and to localize any projectile and/or fragment(s). The latter and any intact portions of involved bone should be retained for possible comparative tool mark analysis.

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