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## Interpretation of Fatal, Multiple, and Exiting Gunshot Wounds by Trauma Specialists

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**ABSTRACT:** Firearm-related injuries are a leading cause of morbidity and mortality in the United States. Trauma care centers and trauma specialists (emergency medicine, trauma surgery, and neurosurgery) provide emergency care for those injured and mortally wounded from firearms. Consequently, trauma specialists may be asked to address forensic questions regarding gunshot wounds. Many firearm-related injuries are nonfatal and ultimately, fatal gunshot wounds can suffer from surgical alteration or, if the time interval between injury and death is prolonged, considerable healing of entrance and exit wounds may occur. Thus, accurate initial evaluation of firearm-related injuries is essential. We reviewed all firearm-related fatalities at our institution over the last five and a half years. Our objective was to determine how accurately trauma specialists can differentiate entrance and exit wounds in fatal perforating (exiting) gunshot wounds and determine the number of penetrating or perforating projectiles in fatal multiple gunshot wounds. A total of 271 fatal gunshot wound deaths were reviewed. Of these, we excluded all fatal penetrating (nonexiting) single gunshot wounds and fatalities not evaluated by trauma specialists. Postmortem findings were compared with the medical records from those individuals seen in the emergency department and/or admitted to North Carolina Baptist Hospital (Level I trauma center). Forty six cases with fatal multiple or exiting gunshot wounds were identified. Twenty four (52.2%) were misinterpreted by trauma specialists. Errors included inaccurate determination of the total number of multiple penetrating and/or perforating gunshot wounds and erroneous identification of entrance and exit wounds. Of the exiting, single gunshot wounds 37% were misclassified and 73.6% of multiple gunshot wounds were interpreted incorrectly. This study emphasizes the need for trauma specialists to be cognizant of the potential for misinterpretation when multiple and exiting gunshot wounds are encountered and realize the medico-legal implications.

**KEYWORDS:** forensic science, wound ballistics, gunshot wounds, trauma specialists, firearm-related injuries

The correct identification of entrance versus exit gunshot wounds (GSWs) and the accurate determination of the number of penetrating or perforating projectiles has important forensic implications. These assessments are made not only by forensic pathologists at autopsy and postmortem examinations, but also by trauma specialists (TS) during physical examination and management of the acutely injured patient [1]. Although not the primary function of trauma specialists caring for seriously injured gunshot wound

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victims, the accurate assessment and classification of GSWs during the initial examination can be critical. Because firearm-related injuries are not uniformly fatal, TS may be the only physicians to examine and evaluate GSWs before surgical alteration, and occasionally, a significant time interval separates injury and death.

Despite the importance of their forensic role, these medical specialists may not possess adequate knowledge of wound ballistics and can misinterpret GSWs [2]. Clearly, the medicolegal implications of such misinterpretations can be devastating. Such erroneous gunshot wound (GSW) evaluations have been highlighted in the John F. Kennedy assassination controversy [3–5]. Nevertheless, a review of the medical literature disclosed no analysis comparing GSW interpretation by trauma specialists with postmortem conclusions made by forensic pathologists. Although several authors state that GSWs are often misinterpreted by trauma specialists, no data have been gathered to support such anecdotal observations [6]. Consequently, we examined the misinterpretation frequency for perforating and multiple GSWs by trauma specialists at a Level I trauma center and report the results of our findings.

### Materials and Methods

We reviewed all firearm-related fatalities examined by the forensic pathology/autopsy service at North Carolina Baptist Hospital over the last five and a half years. Of the 271 GSW deaths, we excluded GSW fatalities not evaluated by TS at the trauma center. Of the 125 fatal GSW cases treated by TS at our institution, all single penetrating (non-exiting) GSWs were excluded from our analysis. Single nonexiting GSWs were omitted because the classification of an entrance wound caused by a nonperforating GSW seemed obvious; however, we discovered a small number of cases where even these were incorrectly categorized. We reviewed the medical records of fatalities resulting from single perforating (exiting) GSWs, multiple perforating GSWs, and multiple penetrating (non-exiting) GSWs. We compared the assessment by the TS with the postmortem findings made by the forensic pathologist. Hospital medical records were reviewed to determine which medical subspecialty initially documented the qualitative and quantitative aspects of the GSW injuries. The medical record review of the GSW fatalities allowed tabulation of how entrance and/or exit wounds were categorized and TS evaluation of the number of GSWs inflicted. Neither caliber estimate nor range of fire was assessed because TS did not routinely address these issues in the medical record. Autopsy reports, postmortem examination diagrams, and photographs were reviewed. The number and location of gunshot wounds were indexed for comparison with the determination made by TS.

### Results

Table 1 outlines the demographics of the 46 GSW fatalities treated by TS. The race of the fatalities was almost evenly divided between blacks and whites. The male to

TABLE 1—*Demographics of the 46 cases seen by TS.*

|                        |    |
|------------------------|----|
| Blacks                 | 23 |
| Whites                 | 22 |
| Race unknown           | 1  |
| Male                   | 40 |
| Female                 | 6  |
| Homicide               | 27 |
| Suicide                | 17 |
| Accident               | 2  |
| Single perforating GSW | 27 |
| Multiple GSW           | 19 |

TABLE 2—*Fatal single exiting and multiple GSW seen by TS.*

|  |    |
|--|----|
| Fatal GSW seen by TS   | 46 |
| Fatal multiple GSW seen by TS  | 19 |
| Fatal single GSW with exits seen by TS                                   | 27 |
| Cases with errors regarding the number of projectiles                    | 15 |
| Cases with entrance versus exit wound errors                             | 16 |
| Cases with entrance/exit wounds and number of projectiles misinterpreted | 7  |
| Fatal GSW cases misinterpreted by TS                                     | 24 |

female fatality ratio was almost 7:1. Homicides comprised 59% of the cases and suicides accounted for 37% of the GSW deaths in the series. Almost 60% of the fatalities were from a single perforating GSW.

Of the 46 GSW deaths from single perforating and multiple perforating or penetrating GSWs evaluated by TS, 24 cases (52.2%) were misinterpreted (Table 2). A total of 15 erroneous interpretations involved the number of projectiles, while 16 misinterpretations involved entrance and/or exit wound determinations. In seven cases (29%), a compounded error occurred where the TS incorrectly recognized the qualitative aspects of the wounds or made an inaccurate assessment of the number of GSWs causing magnification of the error.

For the misinterpreted cases, the length of stay in the hospital ranged from "failed emergent resuscitation" or "dead on arrival" (DOA) to 912 hours (38 days) with a mean of 59.5 hours. The length of hospitalization for the cases interpreted correctly ranged from DOA to 448.75 hours (18.7 days) with a mean of 56.25 hours.

Nineteen fatal, penetrating or perforating multiple GSWs were evaluated by TS at our institution (Table 3). Fourteen cases (73.6%) were misinterpreted. Eleven of the fourteen cases involved incorrect determination of the number of projectiles striking the decedent and nine cases involved errors in entrance/exit determination. In six cases, the number of projectiles and the entrance and/or exit determination were incorrectly evaluated by TS.

Twenty-seven fatal, single perforating GSWs were evaluated by TS (Table 4). Ten cases (37%) were misinterpreted. Five cases involved the erroneous determination of the number of projectiles; nine cases involved inaccurate assignment of entrance/exit wounds. Compounded errors occurred in 40% of the cases misinterpreted. When we examined the manner of death for perforating, single GSWs (Table 5), the error rate for homicides and suicides was about equal (36%). Not surprisingly, compounded errors occurred more frequently with homicides (27%) than with suicides (7%) since self-inflicted, fatal GSWs are infrequently multiple.

TABLE 3—*Fatal multiple gunshot wounds seen by trauma specialists.*

|  |    |
|--|----|
| Fatal multiple GSW cases   | 19 |
| Cases correctly interpreted  | 5  |
| Cases misinterpreted   | 14 |
| Cases with error regarding the number of projectiles                     | 11 |
| Cases with entrance/exit errors  | 9  |
| Cases with entrance/exit wounds and number of projectiles misinterpreted | 6  |

TABLE 4—*Fatal perforating single gunshot wounds seen by trauma specialists.*

|  |    |
|--|----|
| Number of fatal single perforating GSW cases                             | 27 |
| Cases correctly interpreted  | 17 |
| Cases misinterpreted   | 10 |
| Cases with error regarding the number of projectiles                     | 5  |
| Cases with entrance/exit errors  | 9  |
| Cases with entrance/exit wounds and number of projectiles misinterpreted | 4  |

At our institution, the GSW fatalities were evaluated initially by emergency medicine, neurosurgery, and/or trauma surgery (Table 6). Emergency medicine physicians saw the majority of the patients (31/46 or 67%), and misinterpreted eleven of thirty-one cases (35%). Trauma surgery misinterpreted eleven of fourteen cases (79%). Neurosurgery misinterpreted three of seven cases (43%).

Fifty percent of the misinterpreted cases involved GSWs of the head or chest. Thirty three percent of the misinterpreted fatal GSWs involved the abdomen or extremities. The remaining cases were divided between wounds affecting more than one body region.

## Discussion

An entire issue of JAMA was recently devoted to the public health concerns of firearm-related injuries in the United States. The United States has the highest homicide rate of any western industrialized country [7]. Homicide is the second leading cause of juvenile injury-related deaths, second only to motor vehicle accidents [8]. In the United States during 1988, guns were used in  $\frac{2}{3}$ - $\frac{3}{4}$  of all homicidal deaths, almost one third of suicides, and accounted for 2% of unintentional deaths. Firearms are the instrument of death for 34 000 people annually in the United States [9]. Nearly 250 000 nonfatal firearm injuries occur yearly of which one-fourth to one-third require hospitalization [10]. These figures emphasize the medicolegal significance and necessity for correct GSW interpretation by TS.

Interpretation of GSWs involves the science of wound ballistics. This subdivision of terminal ballistics deals with penetration, motion, and effects of missiles on animals. The study of wound ballistics is over a hundred years old and was first scientifically researched at the turn of the century [11].

According to Light, when an entrance wound is produced by a projectile, the size of

TABLE 5—*Perforating single gunshot wounds manner of death.*

| Manner of death | Number of cases | Number of cases correctly interpreted | Number of cases misinterpreted | Cases with error about number of projectiles | Cases with entrance/exit errors | Cases with entrance/exit wounds and number of projectiles misinterpreted |
|-----------------|-----------------|---------------------------------------|--------------------------------|--|---------------------------------|--|
| Suicide         | 14              | 9                                     | 5                              | 1  | 5                               | 1  |
| Homicide        | 11              | 7                                     | 4                              | 4  | 3                               | 3  |
| Accident        | 2               | 1                                     | 1                              | 0  | 1                               | 0  |
| Total cases     | 27              | 17                                    | 10                             | 5  | 9                               | 4  |

TABLE 6—*Trauma specialists interpretation of single perforating and multiple perforating or penetrating gunshot wounds.*

| Specialist         | Total evaluated <sup>a</sup> | Number of cases correctly interpreted | Number of cases misinterpreted |
|--------------------|------------------------------|---------------------------------------|--------------------------------|
| Emergency medicine | 31                           | 20                                    | 11                             |
| Neurosurgery       | 7                            | 4                                     | 3                              |
| Trauma surgery     | 14                           | 3                                     | 11                             |

<sup>a</sup>In some cases, more than one TS initially examined the patient and assessed the GSW(s).

the wound depends upon the size, shape, and velocity of the missile. Because the bullet may expand and tumble as it travels in tissue, the exit wound is often larger than the entrance wound [12]. Nonetheless, the size of the exit wound depends similarly on the size, shape, and velocity of the projectile as it exits the body [13].

However, the medical literature is not entirely consistent about characteristics of entrance and exit wounds. Some authors contend that perforating GSWs caused by handguns often display entrance and exit wounds of similar size, and only with high velocity projectiles do exit wounds occur that are much larger than the corresponding entrance wounds [3].

If one holds strictly to rules about entrance/exit wounds without taking into consideration the missile and weapon used, muzzle-target distance, and the tissues struck, misinterpretation may result. An entrance wound can be larger than the corresponding exit wound and size cannot, therefore, be the sole consideration in deciding entrance versus exit gunshot wounds [14,15].

The inexperienced medical specialist may regard left or right handedness of the decedent as the sole factor in distinguishing between homicidal and suicidal gunshot wounds. Such a rule followed uncritically can mislead the TS in his/her assessment of entrance and exit gunshot wounds. This has been previously documented in case reports of murder versus suicide [16]. The use of the nondominant hand in suicidal gunshot wounds is not an exceptional occurrence [17]. Furthermore, suicide may be due to multiple gunshot wounds, and therefore cannot be ruled out on the basis of projectile number alone [18,19].

Our retrospective analysis indicates the discrepancy rate for interpretations of fatal single perforating and multiple perforating or penetrating GSWs by TS is unacceptably high. Rather than making potentially inaccurate ballistic interpretations, detailed descriptions of gunshot wounds can be augmented by diagrams and photographs whenever possible. Supplemental forensic education concerning wound ballistics must be provided for these medical specialists to reduce faulty medicolegal conclusions.

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