Comparison of the causes of death and wounding patterns in urban firearm-related violence and civilian public mass shooting events

Sam Maghami, MD, Cheralyn Hendrix, MD, Mary Matecki, BS, Karthika Mahendran, MBBS, Richard Amdur, PhD, Roger Mitchell, MD, Francisco Diaz, MD, Jordan Estroff, MD, E. Reed Smith, MD, Geoff Shapiro, EMT-P, *and* **Babak Sarani, MD**, *Washington, District of Columbia*

BACKGROUND: There are no reports comparing wounding pattern in urban and public mass shooting events (CPMS). Because CPMS receive greater media coverage, there is a connation that the nature of wounding is more grave than daily urban gun violence. We hypothesize that the mechanism of death following urban gunshot wounds (GSWs) is the same as has been reported following CPMS.

METHODS: Autopsy reports of all firearm-related deaths in Washington, DC were reviewed from January 1, 2016, to December 31, 2017. Demographic data, firearm type, number and anatomic location of GSWs, and organ(s) injured were abstracted. The organ injury resulting in death was noted. The results were compared with a previously published study of 19 CPMS events involving 213 victims.

RESULTS: One hundred eighty-six urban autopsy reports were reviewed. There were 171 (92%) homicides and 13 (7%) suicides. Handguns were implicated in 180 (97%) events. One hundred eight (59%) gunshots were to the chest/upper back, 85 (46%) to the head, 77 (42%) to an extremity, and 71 (38%) to the abdomen/lower back. The leading mechanisms of death in both urban firearm violence and CPMS were injury to the brain, lung parenchyma, and heart. Fatal brain injury was more common in CPMS events as compared with urban events involving a handgun.

CONCLUSION: There is little difference in wounding pattern between urban and CPMS firearm events. Based on the organs injured, rapid point of wounding care and transport to a trauma center remain the best options for mitigating death following all GSW events. (*J Trauma Acute Care Surg.* 2020;88: 310–313. Copyright © 2019 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Epidemiological, level IV.

KEY WORDS: Firearm; gun; public mass shooting.

The incidence of homicide and unintentional death related to firearm use increased from 3.8 deaths/100,000 people in 2010 to 4.7 deaths/100,000 in 2016.[1] Inclusive of suicides, approximately 38,000 people die annually in the United States due to firearm-related injury, thereby making this a public health problem.[2,3] There are very few well-conducted studies regarding injury patterns and causes of death related to gunshot wounds (GSW). The studies that do exist rarely center on autopsy data, which are the gold standard for determination of cause of death. Additionally, studies related to firearm deaths are often single center in design, thus introducing the potential for sampling bias.

Our group has previously published studies evaluating the wounding pattern and causes of death following civilian public mass shooting (CPMS) events.[4–7] Because CPMS events often receive a great deal of media attention, there is a general feel that these injuries are more grave than those associated with the daily urban firearm violence seen by all metropolitan trauma centers. However, there are no studies to support or refute this connotation. Such studies are needed to determine if similar strategies can be used to treat victims following either event or if disparate strategies are needed for victims of CPMS and urban gun violence.

The purpose of this study was to examine the wounding characteristics following urban firearm-related deaths and to compare these findings to those following CPMS events. We hypothesized that the wounding pattern and causes of death are similar between these two cohorts. If true, our findings could support formulation of similar medical management strategies applicable to either event.

METHODS

The autopsy records of all victims of firearm-related death in the Office of the Chief Medical Examiner of the District of Columbia from January 1, 2016, to December 31, 2017, were reviewed. Patients were excluded if the immediate cause of death on the autopsy report was a long-term medical complication, such as sepsis due to decubitus ulcer in a patient rendered paralyzed from the shooting, rather than an immediate life-threatening injury or if a full autopsy was not performed. The study was deemed to be exempt from IRB review. Hospital records were not used in this study.

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From the Center for Trauma and Critical Care, Department of Surgery (S.M., C.H., M.M., K.M., R.A., J.E., B.S.), Department of Pathology (R.M., F.D.), The George Washington University School of Medicine and Health Sciences; Office of the Chief Medical Examiner (R.M., F.D.); Department of Emergency Medicine (E.R.S.); and Emergency Medical Services Program (G.S.), The George Washington University School of Medicine and Health Sciences, Washington, District of Columbia.

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Address for reprints: Babak Sarani, MD, FACS, FCCM, George Washington University, Department of Surgery 2150 Pennsylvania Ave, NW, Suite 6B, Washington, DC 20037; email: bsarani@mfa.gwu.edu.

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The collected information included age, sex, race, manner of death (homicide, suicide, unintentional, and undetermined), type of firearm used (handgun, rifle, shotgun), and number and anatomic location of GSWs. Each GSW was cataloged by body region as follows: head (including face), neck, chest/upper back (defined as above the costal margin or above the tip of the scapula), abdomen/lower back (including genitalia and buttocks), and extremity. Each skin wound was counted as a separate GSW. For example, a patient who had one chest and one back penetrating wound was cataloged as having two GSWs. Non-penetrating graze wounds were not counted as GSWs. The organ(s) injured and treatment(s) rendered following arrival to the hospital were also recorded.

The results of this study were compared with the autopsy results from events involving CPMSs.[4] Continuous data are summarized as mean with standard deviation (SD) or median with corresponding first and third quartiles (interquartile range [IQR], 25–75) where suitable, and categorical data are presented as percentages. Associations of wound location and event type were examined using Fisher's exact test, first in all cases, then in just the handgun victims (this included nearly all urban shooting victims, and CPMS victims with handgun-only).

For the purpose of drawing conclusions about the equivalence between wounding patterns across event types (urban shooting vs. CPMS), we defined being 'similar' as being within a 15% absolute difference (e.g., a difference in incidence larger than 40% vs. 55% or 30% vs. 45%). This gave us power greater than 0.85 to detect meaningful differences between event types. With this definition, finding no significant difference can be interpreted to mean that the event types have wounding patterns that are broadly similar (i.e., differ by less than 15% in the endpoint of interest).

In addition, to examine whether gun-type, was responsible for the effect of event-type, we did a subgroup analysis in the cases involving only handguns. The sample of urban rifle wounds was too small to analyze statistically.

A two-tailed p value less than 0.05 was considered statistically significant. Data were analyzed using SPSS 25 for Windows (IBM SPSS Statistics, Armonk, NY) and SAS (version 9.4, Cary, NC).

RESULTS

In 2016 and 2017, 575 and 560 people were shot in Washington, DC (personnel communication, Matthew Bromeland, Washington, DC Police Department, April 2019). A total of 186 urban firearm-related autopsy reports were reviewed thus resulting in a case fatality ratio of 33%. The mean (SD) age of patients was 31 (12) years and 166 (91%) were male. The youngest victim was 16 and the oldest 84 years old. One hundred sixty-three (90%) patients were African American, 13 (7%) were Hispanic, and 6 (3%) were white. There were 171 (92%) homicides, 13 (7%) suicides, 1 (0.5%) unintentional, and 1 (0.5%) undetermined intent of death. Almost all victims (97%) were fatally injured with a handgun (180 fatalities). Two (1%) deaths were caused by rifles and none were caused by shotguns.

The number and characteristics of urban GSWs was compared with 21 CPMS events involving 213 victims. The median number of GSWs per victim in urban versus CPMS events was 3 (25,75; IQR, 2–7) versus 4 (IQR, 3–9). As noted in Figure 1, when we ignore weapon type, we find that CPMS victims were significantly more likely than urban shooting victims to have GSWs in the chest/upper back (73% vs. 59%, $p = 0.004$) and in the extremities (54% vs. 42%, $p = 0.02$). The incidence of head wounds was very similar across event types (47% vs. 46%, $p = 0.92$). Incidences of neck (17% vs. 14%, $p = 0.41$) and abdominal wounds (44% vs. 38%, $p = 0.22$) were also similar.

Organ injuries resulting in death following either event were very similar as shown in Figure 2. Incidence of fatal wounding due to a brain injury after CPMS versus urban firearm event was 39% vs. 38% ($p = 0.99$). Despite the fact that gunshots to the chest were more common in CPMS events, there were no

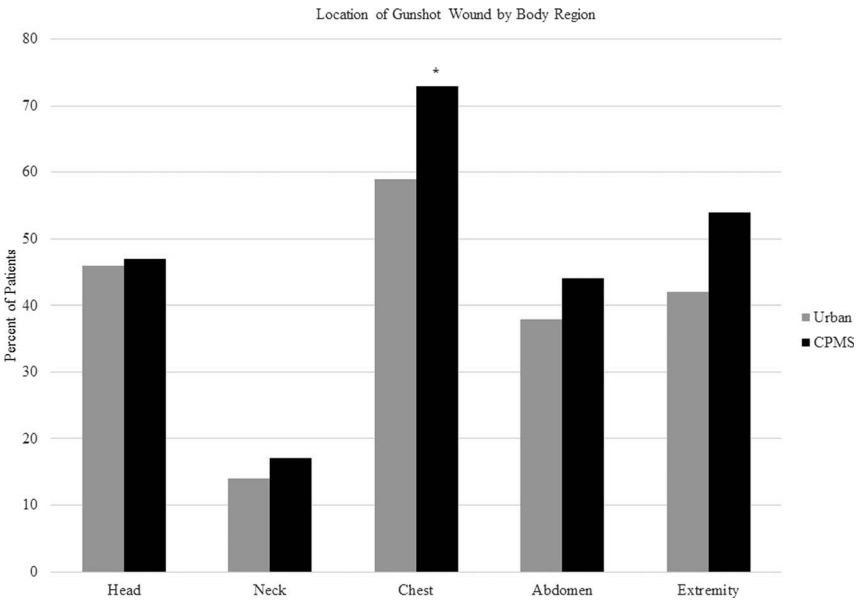

Figure 1. Urban firearm cohort, n = 367 total wounds in 186 victims. CPMS cohort, n = 877 total wounds in 213 victims.[4] * $p < 0.05$.

differences in the incidence of injuries to the lung or heart. Lung parenchymal injury (without concomitant pulmonary hilar or great vessel injury), however, was the second most commonly injured organ that resulted in death in both groups. There were significantly more deaths due to abdominal injury in the urban firearm cohort (15% vs. 25%, $p = 0.012$), although there were little differences noted in actual organs fatally injured between the cohorts. While 42% of patients in the urban firearm injury group and 54% of patients in the CPMS group were shot in an extremity, only 1% of patients in the urban firearms cohort and 3% of patients in the CPMS cohort died because of this.

When we compare event types for the victims shot by handguns only, the results change for head injuries (Table 1). In this subsample of handgun victims, CMPS victims had approximately twice the odds of having a head injury compared with urban shooting victims (63% vs. 47%, $p = 0.034$). They also had approximately twice the odds of having a fatal brain injury (56% vs. 39%, $p = 0.032$).

DISCUSSION

In this retrospective, autopsy-based study we found that the majority of urban GSWs are to the torso and head. Consequently, the most common mechanisms of death were fatal GSWs to the brain, lung parenchyma, and heart. While extremities were the third most commonly injured body area for urban GSWs, these injuries resulted in only one death, making extremity GSWs a rare cause of death following urban firearm violence. Our findings are strikingly similar to the wounding patterns previously reported following CPMS events.[4–7]

Our study provides new insight into the wounding characteristics of fatal urban firearm-related violence. The most common cause of potentially preventable death following CPMS events is lung parenchymal injury without concomitant vascular injury. Our results suggest that this is the case after urban firearm injuries as well. This is surprising because emergency medical services in Washington, DC do not stage and wait for police to secure the scene following a shooting event (personal communication, Dr. Neha Sullivan March 2019). We cannot account for the cause of death in these cases based on the information available in the autopsy reports, but it is possible that these patients died of a pneumothorax. Whereas it is not realistic to teach civilian first care providers maneuvers, such as needle thoracostomy, such a skill could be taught to law enforcement personnel, who are usually the first to arrive to the scene of a shooting. As well, paramedics should be aware of the high incidence of possibly preventable death related to lung injury following GSW events and should have a low threshold to decompress the pleural space in such instances.

This study's findings suggest that prehospital strategies that have been shown to improve outcome following urban firearm-related injury may be equally efficacious in CPMS settings and vice versa. Thus, a similar overall preparedness and training strategy can be used to treat victims of both settings thereby obviating the need for disparate policies and procedures based on event type. Such a strategy should be centered on rapid point of wounding care and transport to a trauma center regardless of the type of event.[8,9] While our study design did not allow us to assess the timeliness or degree of prehospital care rendered, in view of our current and previous findings, we believe that the best possible strategy to mitigate death following urban GSWs is rapid extrication of the victim to advanced medical care.

The strength of this study lies in its design, which included all firearm-related deaths that occurred within the District of Columbia, thereby obviating selection bias regarding those who died, and the use of autopsy data to determine the pattern of

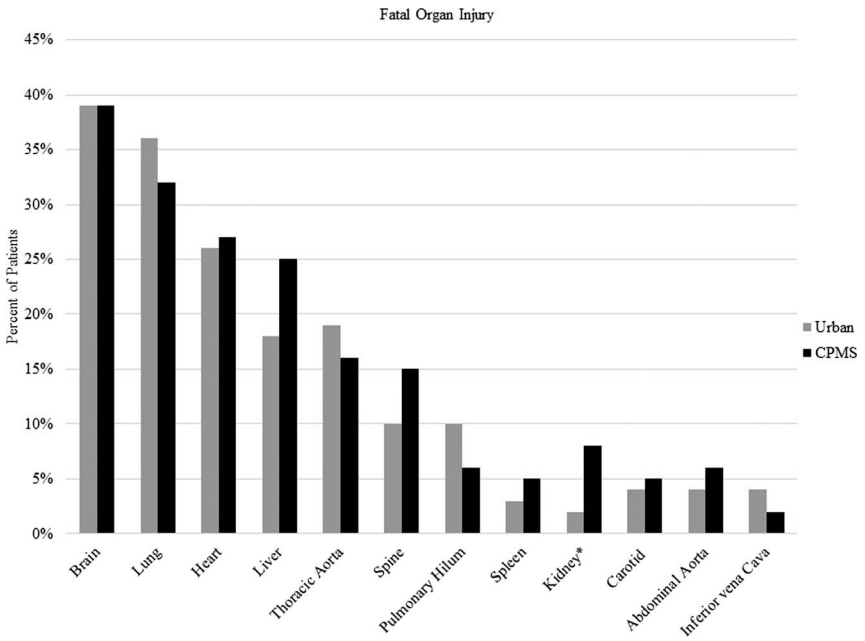

Figure 2. Urban firearm cohort, n = 186 victims. CPMS cohort, n = 213 victims. The total number of organ injuries causing death exceeds the number of persons because a victim could have had more than one fatal organ injury (*$p < 0.05$).

TABLE 1. Association of Outcomes With Event-Type in Handgun Cases

Outcome	CPMS	Urban	Odds Ratio (CI)	*p*
Wound location				
Head/face	36 (63%)	84 (47%)	1.96 (1.06–3.62)	0.034
Neck	10 (18%)	26 (14%)	1.26 (0.57–2.80)	0.53
Chest/back	40 (70%)	107 (59%)	1.61 (0.85–3.05)	0.16
Abdomen	28 (49%)	68 (38%)	1.59 (0.87–2.90)	0.16
Extremity	27 (47%)	75 (42%)	1.26 (0.69–2.29)	0.54
Fatal wound location				
Head/face	32 (56%)	71 (39%)	1.97 (1.08–3.59)	0.032
Neck	2 (4%)	12 (7%)	0.51 (0.11–2.35)	0.53
Chest/back	26 (46%)	93 (42%)	0.78 (0.43–1.43)	0.45
Abdomen	9 (16%)	46 (26%)	0.55 (0.25–1.20)	0.15

Note: There were insufficient number of urban injuries using rifles or shotguns to allow analysis.
CI, confidence internal.

organs injured. However, the study has several limitations, which we acknowledge. As with any other examination of a\utopsy data, there is an inherent risk of selection bias as we only examined patients who did not survive. As such, we make no comments regarding wounding patterns in those who survived a GSW following either urban gun violence in Washington, DC or a CPMS event. There is no question that the survivor cohort needs to be evaluated as well, but such a study necessitates identifying the survivors and accessing their medical record. Such a task was beyond the confines of our study. The 15% difference cutoff as the definition of similar or different between the cohorts is arbitrary, but we feel that it is clinically relevant when trying to measure differences in wounding patterns. Next, although Washington, DC is a major metropolitan setting, the study is still based on a single urban area, and its findings may not be applicable to other cities with differences in the public safety response structure and transport time to trauma centers. Because our study was based solely on autopsy results, we are not able to determine the time from the shooting event to paramedic arrival on scene. Lastly, there was no information regarding bullet caliber and jacketing in the autopsy reports. Both of these factors are strongly associated with lethality of gunshots.

CONCLUSION

In conclusion, gunshot wounds to the head and torso constitute the majority of injuries following both urban firearm and CPMS events, and the most common cause of potentially preventable death following either event is isolated lung injury. Rapid point of wounding care offers the best chance to mitigate death following any firearm-related injury.

AUTHORSHIP

B.S., R.M., F.D., J.E., E.R.S., G.S. participated in the study design. M.M., S.M., K.M. participated in the data collection. B.S., R.A., J.E., R.M., F.D., C.H. participated in the data analysis and interpretation. B.S., R.A., J.E., E.R.S., G.S., C.H. participated in the writing and critical revision.

DISCLOSURE

E.R.S. and G.S. voluntarily serve on the Executive Board of the Committee for Tactical Emergency Casualty Care. Dr. Sarani voluntarily serves on the Board of Directors of the Committee for Tactical Emergency Casualty Care. Funding Source: None.

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