Radiology and Gunshot Trauma:
Healthcare Outcomes and Forensic Autopsy

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Learning Objectives

After reading this article, the reader should be able to:

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- Identify bullet types and gunshot injuries.
- Understand the importance of surgical intervention and interventional radiology for gunshot patients.
- Explain the advantages and disadvantages of CT and MRI for diagnosing and treating gunshot injuries.
- Understand the role of radiology with craniocerebral gunshot trauma.
- Provide coping resources for gunshot patients and healthcare personnel.

Abstract

Radiology and Gunshot Trauma: Healthcare Outcomes and Forensic Autopsy

Most hospitals, radiology departments, and forensic pathology labs will encounter a gunshot trauma victim. Gun violence has been steadily on the rise in the United States. There are a variety of scenarios that could result in gunshot trauma. A gunshot injury could be caused by suicide, homicide, legal intervention (police, security, and/or militia), mass shootings, or be deemed unintentional.[1] Radiology plays a large role in the short term and long term care of these trauma patients within healthcare settings. Radiography, fluoroscopy, computed tomography (CT), magnetic resonance imaging (MRI), interventional radiology, and ultrasound are utilized to provide medical imaging of gunshot victims. Forensic pathology labs also rely on radiologic imaging, particularly CT and MRI. These imaging modalities help confirm autopsy reports for fatal gunshot victims. Digital radiology has drastically impacted and improved the outcomes of fatal and non-fatal gunshot injuries.

Whether pertaining to forensics or diagnoses, gunshot trauma victims and healthcare personnel rely heavily on radiologic imaging. Approximately 115,000 U.S. citizens will fall victim to a non-fatal gunshot wound this year.[1] There will also be approximately 40,000 fatal gunshot wounds throughout the year.[2] The leading cause of gunshot-related death is suicide (61%), and the second leading cause is homicide (35%).[1] A small fraction of gunshot deaths result from mass shootings, legal intervention (police, security, and militia), or are unintentional.[1] Despite the large quantity of gunshot-related incidences, there are still healthcare employees who are not familiar with or educated on the subject. Radiology personnel must be prepared for any potential trauma that may come through the hospital doors. Whether it is a new gunshot victim being rushed to the emergency department or a follow-up appointment for a gunshot victim in recovery, radiology personnel should be informed of the subject to provide the best possible care. Radiology personnel should also be informed of the different types of gunshot wounds, the best radiologic imaging modality for gunshot trauma, and how to support a patient that has a traumatic injury.

Firearms and Bullets

The most common type of firearm used for gunshot murders in the United States is a handgun (64%).[2] Rifles pertain to 4% of gunshot wounds, and shotguns pertain to 2%.[2] The remaining 30% involves unspecified gun types.[2] There are a variety of bullet types on the market. The most common type has a lead core with a casing.[3] A projectile bullet can travel up to 1,500 meters per second, which is equivalent to 3,355 miles per hour.[3] The speed (low-velocity VS. high-velocity) of the bullet is dependent on the type of ammunition, gun, and the distance from the target.

A bullet wound can be inflicted in a variety of ways. One way involves the bullet crushing structures along its track.[3] Shearing and compression of the tissue can cause tearing of structures, (e.g. abdominal organs) or stretching of structures that are not typically elastic, (e.g. brain).[3] If the bullet exits the body, the tissue will recoil and hot gases will dissipate.[3] Another way for a bullet wound to be inflicted involves kinetic energy.[3] Kinetic energy may be transferred from the bullet and into the surrounding tissues which ultimately causes damage to the outside of the bullet track.[3] The extent of the damage due to kinetic energy transfer is dependent on the velocity and mass, projectile fragmentation, and the entrance point of the bullet.[3]

Bullet Injury Types

When working with a gunshot patient, it is important for both the technologist and radiologist to be aware of the different types of injuries that may result from the trauma. Tissue disruption is usually minor if a bullet still appears whole, there is no visible fracture, and the bullet is only present in the soft tissue.[4] If a cluster of bullet fragments appear on an x-ray or computed tomography (CT) scan, then significant tissue damage is likely.[4] If a bullet strikes bone, it is more likely to disperse and cause migration of bullet fragments.[4] Major vessel or nerve disruption could also indicate significant damage.[5] The most common types of fractures caused by gunshot trauma are divot, drill-hole, butterfly, and double butterfly fractures.[4] It is possible that a bullet could ricochet off of anatomy and come to a stop in an area of the body that is far away from the bullet wound. Additional x-ray and CT imaging should be obtained to observe or rule out a bullet in the anatomy.

Medical Intervention for Gunshot Patients

Immediate medical intervention is required for a gunshot victim in order to increase the chance of survival, acquire a prognosis, and obtain an effective healthcare outcome. Gunshot wound complications include lead intoxication, neurotoxicity, anemia, emesis, abdominal colic, and deformity.[6] Physicians utilize a variety of imaging modalities to examine the extent of a gunshot injury. X-ray and CT aid in the initial prognosis. X-ray helps determine if there is any bone involvement or any potential fractures from the bullet wound.[6] CT helps visualize the impact of the bullet wound on the internal organs, blood vessels, and other surrounding tissue.[6] Radiologists are required to perform a FAST protocol when examining bullet trauma radiography.[4] A FAST protocol involves a quick search for free abdominal fluid, a pleural effusion, or injury to the spleen, liver, kidneys, and aorta.[4] If a bullet wound is near the pelvis or lower half of the vertebral column, there is most likely a bowel injury.[6] Both x-ray and CT examinations will help the radiologist and physician determine if the patient requires operative interventions. Surgical intervention may include ORIF/external fixation, arthrotomy, surgical debridement, intramedullary nailing, surgical decompression, or bullet fragment removal.[6] Non-operative measures for a gunshot wound may include wound care, oral antibiotics, and a tetanus shot.[6]

Due to the efficiency of present day imaging (digital radiology VS computed radiology VS film processing), patients are more likely to have a successful recovery and healthcare outcome. One benefit to using digital radiography is the patients that require surgical intervention are able to get on the operating table sooner. Another benefit includes the utilization of interventional radiology. X-ray and fluoroscopy help the interventional radiologist determine almost immediately if the patient has internal bleeding and if it needs to be addressed.

Surgical Intervention for Gunshot Patients

If a gunshot patient requires surgery, there will be a large group of healthcare staff surrounding the patient in an effort to save their life. A radiologic technologist may be required to obtain C-arm or O-arm x-rays during the surgical case. The radiologic technologist must understand the role of the other healthcare staff in the operating room in order to understand the workflow and expectations.

The operating room will consist of a surgeon, anesthesiologist, surgical technologist, and a registered nurse. The surgeon will ultimately determine the plan of care for the gunshot patient.

The anesthesiologist also plays an incredibly vital role in the recovery of the patient. The anesthesiologist will insert a breathing tube, manage the status of the patient's breathing, and treat any potential fatal acidosis.[7] They will also administer life-saving medications, fluids, and transfuse blood, as needed.[7] The anesthesiologist will monitor the patient's electrolytes, body temperature, blood loss, urine output, and cardiac output.[7] More often than not, a gunshot patient will be too unstable to go under the influence of anesthesia. It is common for patients to still be conscious and aware during trauma surgery.[7] While the anesthesiologist is monitoring the patient, the surgeon will work quickly to identify and treat the gunshot wound.[7] At times there will be more than one injury for the surgeon to assess. The surgeon will rely on radiologic imaging to help detect the path of the bullet and the extent of the damage. It may be difficult for a surgeon to identify the anatomy through radiographic imaging due to the deformation of organs, bone, blood vessels, and soft tissue.[7] Another crucial staff member to the surgery department is the registered nurse. The nurse will fetch surgical supplies and document patient care, as needed. The nurse will also aid in the transportation and hand off of the trauma patient to a new nurse after the patient has completed surgery. The surgical technologist will ensure an aseptic environment is maintained throughout the operation and will prepare necessary tools for the surgeon.

The radiologic technologist must be educated on the importance of an aseptic environment and must be cautious when maneuvering x-ray equipment in a busy, adrenaline-filled operating room. The radiologic technologist must also have effective communication skills and be able to follow instructions from the surgeon as they are requesting fluoroscopy and x-ray imaging. If the gunshot patient survives surgical intervention, they will be transported to the intensive care unit (ICU) afterwards. More radiologic imaging will be obtained via x-ray and CT scan while the patient is recovering in the hospital within the ICU and later on in acute care.

Interventional Radiology for Gunshot Patients

Along with surgery, interventional radiology is also heavily relied upon for gunshot trauma. It is common for gunshot patients to receive an angiogram and embolization. These procedures are performed in an aseptic environment by an interventional radiologist, radiologic technologist, and registered nurse in a catheterization laboratory.

An angiogram procedure involves x-ray and fluoroscopy of the blood vessels.[8] It is typical for contrast media to be used to visualize the networking of the blood vessels.[8] Interventional radiologists perform an angiogram so they can see the presence or absence of trauma to the blood vessels. When a blood vessel has ruptured, a patient may experience internal bleeding. If an angiogram can be safely performed on a patient pre-operative, then another angiogram may be performed post-operatively.[5] This is done to help ensure there are not any areas of abnormal bleeding that were overlooked.[5] The simple step of performing an angiogram before and after a procedure will increase the chances of patient survival.[5]

An embolization procedure is minimally invasive, and it is performed to decelerate internal bleeding.[9] Embolization involves the use of medications and embolic agents that are sent through a catheter into the blood vessels.[10] The agents decrease blood flow near the injured vessel, which encourages clot formation.[10] One advantage of an embolization is that it can slow hemorrhage before a patient is taken to surgery. However, if an embolization cannot be performed quickly and safely due to the severity of the trauma, the patient should return to the care of the surgeon for alternative treatment.

Ultrasound and Gunshot Trauma

Ultrasound plays a small yet vital role in the treatment of gunshot traumas. Ultrasound is utilized during interventional radiology and surgical procedures. It is common to use this particular imaging equipment to gain catheterization access to the blood vessels. Ultrasound is also useful if emergency department personnel are trying to detect any abnormal placement of fluid within the abdominal cavity.[11] Ultrasound is quick, affordable, and easily-accessible.[11] There is little research on the effectiveness of ultrasound as an independent imaging modality for gunshot trauma patients.[11] Though ultrasound is semi-effective in detecting superficial bullet fragments, it is not the preferred imaging modality for these particular traumas. Ultrasound tends to be more of a supplemental imaging modality for gunshot patients.

Advantages and Disadvantages: Computed Tomography and Gunshot Trauma

Each radiologic modality has advantages and disadvantages to obtaining images of gunshot wounds. Computed tomography (CT) is one of the more effective imaging modalities when it comes to the examination of gunshot trauma. While assessing a trauma patient, physicians prefer to utilize the imaging modality that can provide the fastest and highest quality results. A CT scan takes approximately 10-30 minutes to complete and creates detailed imaging that is ideal for diagnosis and treatment. CT can help locate a projectile bullet path throughout the anatomy. Typically the bullet path is straight. However, it is possible for bullets to ricochet off of body structures, particularly bone.[5] Bullets will occasionally ricochet off of the anatomy and settle in an area of the body that is far away from the bullet track. It is important that physicians search all areas of the CT image for bullets. A disadvantage to using a CT scanner to detect a bullet is the presence of a "star" or "streak" artifact. This artifact results from a bullet that is still lodged within the anatomy. The CT scanner beam is absorbed by the dense metal object (bullet). Once this happens the machine cannot properly process the data throughout the image construction process which results in the streak artifact.[12] An artifact may interfere with an accurate diagnosis.

Computed Tomography and Forensic Autopsy

Computed tomography is also used frequently in the field of forensics. PMCT is the abbreviation for post-mortem computed tomography. CT does not substitute for an autopsy, however, it does facilitate with the forensic findings of an autopsy.[13] Both the autopsy and the CT are complementary to one another and can confirm professional conclusions and cause of death for most gunshot fatalities.[13] Computed tomography machines can produce a 3-D reconstruction of the anatomy which helps with exact bullet localization and retrieval during an autopsy. The images can also help with the identification of the ammunition type. The scanner can help detect subtle fractures and small bullet fragments that may otherwise be overlooked during an autopsy. One disadvantage to using CT in the aid of a gunshot autopsy is that there is no color discrimination to help determine the type of fluid or anatomy that is being viewed.[13]

Advantages and Disadvantages: Magnetic Resonance Imaging and Gunshot Trauma

Magnetic resonance imaging (MRI) is not typically relied upon in the examination and diagnosis of non-fatal gunshot trauma.[14] An MRI technologist must thoroughly investigate a patient's medical history to ensure the patient has not had a gunshot wound in the past prior to the MRI scan. Despite the removal of the bullet, there may still be bullet fragments within the anatomy. The heating of the bullet fragments within an MRI scanner may pose concern.[14] Most present day bullet fragments are not ferromagnetic, however, there are some exceptions.[14] A few of those exceptions include shrapnel in war veterans, shotgun pellets used for duck hunting in the United States, and certain types of bullet jackets (nickel or steel).[14]

It is vital for the physician, radiologist, and MRI technologist to discuss the risks and benefits before sending a gunshot patient through an MRI scanner. The MRI scanner is an optional imaging modality for gunshot victims, however, only under specific circumstances. If a streak or star artifact is present on a CT scan, it may obscure the image. When this happens, MRI may be the next option for radiologic imaging.[14] MRI may also be useful in better visualizing soft tissue damage after a gunshot injury.

Magnetic Resonance Imaging and Forensic Autopsy

It is not uncommon for an MRI scanner to be used on post-mortem gunshot victims in order to obtain forensic information. MRI can provide high quality images of soft tissue which is deemed useful for the autopsy and legal investigation. A preliminary CT scan is performed first to rule out the presence of ferromagnetic bullets. If no bullet fragments are present, an MRI scan will be performed to gain more detailed images of soft tissue damage due to a bullet wound.[15] The MRI can help the forensic radiologist identify leftover residues, the entrance and exit site of the bullet wound, and the direction that the bullet went through the patient.[15] MRI can also detect small microbleeds, injuries, and pathologies.[15] These findings help histology personnel obtain more precise tissue samples that aide in the autopsy.[15]

Craniocerebral Gunshot Injuries

There are many different types of injuries that involve gunshot trauma. One area of interest is gunshot trauma to the head. As mentioned earlier, 61% of gunshot-related injuries are due to suicide attempts.[1] Unfortunately, it is common for people to attempt suicide via a projectile bullet to the craniocerebrum. These injuries can be detrimental, though, patients have

been known to survive. Often there are long-term complications as a result from the gunshot trauma. Radiologic imaging can help the radiologist and neurosurgeon determine if the bullet wound is a closed head trauma, (an injury that does not go through the skull), or if brain tissue has been penetrated and damaged.[16] Prognosis for a craniocerebral gunshot injury is poor. Approximately 90% of these gunshot patients die before arriving at the hospital, and of the 10% that do arrive at the hospital, 50% will die in the emergency department.[16] The survival rate is 7-15%.[16] Healthcare personnel must work quickly to increase the likelihood of survival for craniocerebral gunshot patients.

Computed tomography and magnetic resonance imaging are used to help neurosurgeons determine a prognosis. CT can provide fast image outcomes which, in turn, leads to the patient receiving necessary surgical care faster. CT displays bones better than soft tissue. If a bullet does penetrate the brain, MRI is favored. MRI allows the physician to observe soft tissue damage and patterns of internal bleeding. An MRI scan is not a fast process which is not ideal for a trauma situation. CT is used more often than MRI with craniocerebral gunshot wounds. The neurosurgeon will assess the patient's pupil response and whether or not the patient is hypotensive before sending them to CT. While the patient is in the emergency department CT scanner, the registered nurse, neurosurgeon, and other trauma staff will be present to help monitor the status of the patient. The CT technologist does not administer contrast during these particular head scans. Head trauma patients are typically unstable and should not be given contrast if there is any chance of liver failure or unknown, abnormal bleeding. Once the neurosurgeon has observed the patient's CT scan, they will plot a surgical intervention for the patient.

There is controversy over the best surgical intervention for craniocerebral gunshot patients. Some surgeons prefer to treat the wound with minimal cerebral debridement while preserving as much cerebral tissue as possible.[16] Other neurosurgeons remove all bone and metallic fragments that are accessible to decrease the risk of infection.[16] It is possible that the neurosurgeon may decide to refrain from patient treatment completely if they feel that the patient is in poor condition and has multiple negative prognostic variables.[16] Negative prognostic variables may include severe disability or a persistent vegetative state.[16]

Intracranial hypertension (ICH) is the leading cause of death for patients with a traumatic brain injury (TBI).[16] Hematomas, cerebral edema, and hydrocephalus can cause an increase in

intracranial pressure.[16] If intracranial pressure is left untreated the compression on the brain could cause the brain to move down into the brain stem which can be detrimental.[17] The treatment measures for a TBI involve hyperventilation, cerebral spinal fluid drainage, and decompressive craniectomy.[17] A decompressive craniectomy is the removal of a portion of the skull so the brain has space to swell without compression.[17] Once a portion of the skull has been removed the skull fragment will either be placed in a freezer or in a small pouch of the patient's body so that the skull fragment can be put back in the patient's head after recovery.[17] There is potential for permanent brain damage after a TBI and craniectomy. A few other complications may include brain or spine infection, inflammation, loss of the ability to speak, full or partial paralysis, lack of awareness, coma, and death.[17]

In order for a craniocerebral gunshot patient to have a better chance at survival, it is vital that healthcare staff work diligently and efficiently. This includes the radiology team, since medical imaging must be obtained quickly to assess the degree of damage to the brain and to create a surgical treatment plan for the patient.

Coping Resources for Gunshot Victims

Gun violence victims tend to have a long recovery, not only physically, but mentally and emotionally. These victims may sustain deformation of anatomy after a gunshot injury. The deformation could be present on any part of the body. If deformation is present on the face, it may take the victim years to cope and accept the deformation. Other physical symptoms that a gun violence victim may experience include headaches, sleeping too much or too little, tachycardia, stomach ache, being easily startled, PTSD, exhaustion, hopelessness, panic, anxiety, fear, and guilt.[18] Gun violence victims may feel isolated or have a lack of interest in things that they once enjoyed.[18] There are an array of resources for gun violence victims who are struggling to heal after trauma. It is important for healthcare personnel to display patience, compassion, and empathy towards gun violence victims. These patients are advised to limit television, radio, and social media exposure. The information through these media outlets may trigger a memory (gun violence flashback) or cause more sorrow and anxiety for this particular population.[18] Healthcare personnel should take initiative and turn off any nearby televisions or radios in waiting areas and hospital rooms before patient arrival.[18] Healthcare personnel should also try not to judge or inappropriately stare at gunshot scars as this may affect a patient's self-esteem and confidence.

Coping Resources for Healthcare Personnel

Hospital staff witness a variety of illnesses, wounds, and injuries. Hospital staff also experience long hours with few breaks. It may be difficult for healthcare staff to process and cope with the sighting of a gunshot victim, especially since the probability of death is more likely than with most other injuries. It is not uncommon for healthcare staff, particularly physicians, to feel burned out or clinically depressed. Depressed hospital staff may experience work errors and a lack of compassion for patients. Long-term effects of depression may result in heart disease, high blood pressure, obesity, and premature death.[19] Healthcare employees may also experience sadness, irritability, absenteeism, and difficulty falling asleep. It is common for healthcare employees to need emotional support in order to cope with the trauma sightings, long hours, and burn out. Healthcare employees should be encouraged to set up an appointment with a counselor, therapist, or physician to address depression and burnout. Another coping strategy entails that a healthcare employee should take a break from work for a day and do something that they enjoy. A few examples of an efficient mental health break include visiting family or a friend, exercising, shopping, or getting a massage.[19]

Conclusion

Ultimately, it is the radiologic technologist's responsibility to acquire high quality images to aid in the survival, recovery, or autopsy of gunshot patients. Gunshot trauma patients could require imaging via x-ray, computed tomography, magnetic resonance imaging, interventional radiology, and ultrasound. These imaging modalities assist in the short term and long term care of these patients. It is the radiologist's responsibility to detect the bullet track, location of secondary missiles, the organs that were injured, and what body compartments were damaged.[5] Surgeons and radiologists work closely to diagnose and treat gunshot trauma patients. Angiography, embolization, and surgery are complementary treatments for these particular wounds.[10] It would be difficult to create treatment plans without radiologic imaging. Gunshot patient healthcare outcomes have improved due to digital radiology equipment and the ability of the machines to obtain and load an anatomical image quickly. Forensics also benefits from the usage of radiologic imaging. Autopsies of gunshot victims are more accurate due to access of x-ray, CT, and MR imaging.[13]

References:

1. UC Davis Health. Facts and Figures. 2020. Available at: https://health.ucdavis.edu/what-you-can-do/facts.html Accessed November 16, 2020.

2. Gramlich, John. What the data says about gun deaths in the U.S. 2019. Available at: https://www.pewresearch.org/fact-tank/2019/08/16/what-the-data-says-about-gun-deaths-in-the-u-s/ Accessed November 16, 2020.

3. Gurvinder, Rull. Gunshot Injuries. 2014. Available at: https://patient.info/doctor/gunshot-injuries Accessed November 16, 2020.

4. D. Garcia Casado. A. Garrote. J. Á. Santos Sánchez. K. El Karzazi Tarazona. J. Sánchez Hernández. N. D. Menocal Funez. Et al. What radiologists can say about gunshot wounds and stab wounds: clinical, radiological and forensic approach. *ESR.* 2012; volume 1: 1-19.

5. Hollerman JJ, Fackler ML, Coldwell DM, Ben-Menachem Y. Gunshot wounds: 2. radiology: *AJR*. 1990 October; volume 155: 691-702.

6. Weatherford, Brian. Gun Shot Wounds. 2020. Available at: https://www.orthobullets.com/trauma/1059/gun-shot-wounds Accessed November 16, 2020.

7. Busch, Justin. Trauma Surgery: What a Gunshot Wound Patient Can Expect in the Operating Room and Intensive Care Unit. 2019. Available at: https://affirmresearch.org/2019/01/28/trauma-surgery-what-a-gun-shot-wound-patient-can-expect-in-the-operating-room-and-intensive-care-unit/ Accessed November 16, 2020.

8. Eske, Jamie. What to know about angiograms. 2019. Available at: https://www.medicalnewstoday.com/articles/326825#uses Accessed November 16, 2020.

9. Vedelago, John. Dick, Elizabeth. Thomas, Robert. Jones, Brynmor. Kirmi, Olga. Becker, Jennifer. Et al. Look away: arterial and venous intravascular embolisation following shotgun injury. *J Trauma Manag Outcomes.* 2014 November 15; volume 8(19): 1-4.

10. Radiology Society of North America, Inc (RSNA). Catheter Embolization. 2020. Available at: https://www.radiologyinfo.org/en/info.cfm?pg=cathembol Accessed November 16, 2020.

11. Burns, Brian. Bedside emergency department ultrasound in assessment of a gunshot wound. *Australas J Ultrasound Med.* 2015 December 31; volume 1: 1-2.

12. Dvorsky, George. This is what happens when you try to scan a brain with a bullet in it. 2013. Available at: https://io9.gizmodo.com/this-is-what-happens-when-you-try-to-scan-a-brain-with-1456875477 Accessed November 16, 2020.

13. Lathrop, Sarah. Nolte, Kurt. Utility of postmortem x-ray computed tomography (CT) in supplanting or supplementing medicolegal autopsies. *NIJ.* 2016 June; volume 1: 1-98.

14. Deng, Francis. Stanislavsky, Alexandra. Imaging of shotgun injuries. 2020. Available at: https://radiopaedia.org/articles/imaging-of-gunshot-injuries-1?lang=us Accessed November 16, 2020.

15. Gascho, Dominic. Deininger-Czermak, Eva. Zoelch, Niklaus. Tappero, Carlo. Sommer, Stefan. Hinterholzer, Natalie. Et al. Noninvasive 7 tesla MRI of fatal craniocerebral gunshots – a glance into the future of radiologic wound ballistics. *Forensic Sci Med Pathol.* 2020 September 12; volume 16: 595–604.

16. Alvis-Miranda, Hernando. Rubiano, Andres. Agrawal, Amit. Rojas, Alejandro. Moscote-Salazar, Luis. Satyarthee, Guru. et al. Craniocerebral gunshot injuries; a review of the current literature. *Bull Emerg Trauma.* 2015 December 29; volume 4(2): 65-74.

17. Jewell, Tim. What is a Craniectomy? 2018. Available at: https://www.healthline.com/health/craniectomy Accessed November 16, 2020.

18. Every Town for Gun Safety Support Fund. Trauma and Gun Violence. 2020. Available at: https://everytownsupportfund.org/everytown-survivor-network/resources-for-victims-and-survivors-of-gun-violence/trauma-and-gun-violence/ Accessed November 16, 2020.

19. Matthews, Kayla. Let's talk about mental health...in hospital staff. 2019. Available at: https://healthcareinamerica.us/lets-talk-about-mental-health-in-hospital-staff-8c076a2ba315 Accessed November 16, 2020.