Seminars in ULTRASOUND CT and MRI

Imaging Assessment of Gunshot Wounds

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Gunshot injuries occur when someone is shot by a bullet or other sort of projectile from a firearm. Wounds are generally classified as low velocity (less than 609.6 m/s) or high velocity (more than 609.6 m/s). Those with higher velocity may be expected, on this basis, to dissipate more energy into surrounding tissue as they are slow and cause more tissue damage, but this is only a very approximate guide. However, these terms can be misleading; more important than velocity is the efficiency of energy transfer, which is dependent on the physical characteristics of the projectile, as well as the kinetic energy, stability, entrance profile and path traveled through the body, and the biological characteristics of the tissues injured. Hemodynamically stable patients and patients who stabilized after simple immediate resuscitation were evaluated with a careful history and physical examination. A routine x-ray is performed in patients with gunshot wounds. Indication for total body computed tomography (CT) is based on the presence of signs and symptoms of vascular damage at clinical examination. Patients are immediately transferred in the operating room for surgery if more serious injuries that require immediate surgical care are not diagnosed, or hemostasis may be preliminary reached in the emergency room. Hemodynamically stable patients with no history and clinical examination showing suspected vascular damage are allowed in the radiology department for obtaining a total body CT scan with intravenous contrast medium and then transferred to the surgical ward trauma for observation. After 24 hours without the complications, patient can be discharged. CT is the procedure of choice to identify hemorrhage, air, bullet, bone fragments, hemothorax, nerve lesion, musculoskeletal lesions, and vessels injuries and is useful for assessing medicolegal aspects as trajectory and the anatomical structures at risk.

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Introduction

Gunshot injuries occur when someone is shot by a bullet or other sort of projectile from a firearm. Peace time gunshot injuries occur in a variety of different situations—criminal and terrorist incidents (including shots fired by law enforcement agents), attempted suicides, and unintended firearm "accidents" (both civilian and among the armed forces).[1] Gunshot wounds (GSWs) are now the second leading cause of death and injury for the youth, especially African Americans, killing more teenage boys than all natural causes combined.[2-4] The homicide rate for male adolescents aged 15-24 years in the United States is roughly 20 times higher than that in other industrialized nations.[3] The economic effect of gunshot trauma is also high. At an intercity hospital, the annual costs for the treatment of these injuries can easily reach $50 million.[3] Nationwide, the calculated costs of medical treatment, mental health care, emergency transport, police services, and insurance administration exceed $2.7 billion annually,[5] most of which is borne by the American taxpayers.[4,6] For every gunshot homicide, there are 3.3 nonfatal injuries.[3,5] One of these is a brain or spinal cord injury, leading to lifetime expenditures in excess of $3 million.[3] Wounds are generally classified as low velocity (less than 609.6 m/s) or high velocity (more than 609.6 m/s). Those with higher velocity may be expected, on this basis, to dissipate more energy into surrounding tissue as they slow and cause more tissue damage, but this is only a very approximate guide. This kinetic energy dump theory is controversial, as high-velocity injuries are frequently less extensive than would be predicted, and

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fragmentation appears to be the most effective mechanism for wounding rather than yawing or other mechanisms for slowing high-velocity rounds quickly. However, these terms can be misleading; more important than velocity is the efficiency of energy transfer, which is dependent on the physical characteristics of the projectile, as well as kinetic energy, stability, entrance profile, and path traveled through the body, and the biological characteristics of the tissues injured. Although bullets are not sterilized on discharge, most low-velocity GSWs can be safely treated nonoperatively with local wound care and outpatient management. Shotguns, for example, are technically low-velocity weapons but are responsible for substantial rates of major soft tissue, nerve, vascular, bone, and joint injuries,[6-8] resulting in a mortality rate nearly twice that attributable to other weapons. More appropriate are the designations “low-energy” and “high-energy,” which are descriptive of the amount of damage to the tissues. To appreciate this distinction, the factors that affect the transmission of the wounding capacity of a missile to the tissues must be considered. The mechanisms by which projectiles, such as those discharged from firearms (eg, bullets), cause tissue injury (terminal ballistics) are crushing and stretching—that is, shockwave formation and temporary cavitation.[9,10]

The lethality of a projectile relates significantly and directly to its deformability and the degree of fragmentation it undergoes in the target. The Hague Convention of 1899 has strict specifications for military-use bullets in order to limit the lethality of such ammunition; true full-metal jacketed military bullets resist deformation and fragmentation and are in fact designed to wound but not to kill. The harsh reality of warfare philosophy is that the soldier wounded but not killed by a bullet on the frontline is a far greater drain on the economy and manpower resources of the enemy than is a fatality. In general, bullet wounds (and, in fact, any projectile wound) are more severe when the projectile yaws through tissue, when the projectile fragments or deforms (eg, into a mushroom shape), when the projectile is large, or when the projectile is traveling at high velocity.[11] One of the “recommendations” of the hollow-point and soft-point bullets (the former are used by specialist firearms officers in the UK) is that they are less likely to exit the target, which poses a smaller risk to bystanders. The lethality of the hollow-point and the soft-point bullet is therefore very high, and it is for this reason that this type of ammunition is also used in hunting, supposedly expediting death of the target animal as rapidly and as humanely as possible. The terminal ballistics of shotgun injuries warrant special consideration: shotgun pellets create tissue damage proportional to the distance from the target, proportional to the number of pellets that hit the target, and proportional to the size and pattern of the pellet strike.

The most important factors in causing significant injury or death are their placement and projectile path. The head and torso are the most vulnerable areas.[12] The extent of tissue and organ trauma depends on terminal ballistics, which is influenced by the type of bullet, its velocity and mass, and the physical characteristics of the penetrated tissue. All patients with nontrivial gunshot injuries need cross-matching of 6 units of blood, and at least one and, preferably, 2 large-bore intravenous (IV) cannulae are required for vigorous fluid replacement.

However, hypertension should be avoided, which may exacerbate blood loss; a systolic BP of 100-110 mm Hg should be the aim. Vital signs, blood gases, and electrocardiogram (ECG) monitoring should be carried out. High-dependency or intensive care should be provided. When faced with GSWs, there are further useful questions a doctor can ask: (1) What type of weapon was used? For example, small handgun, a shotgun, or high-powered rifle (if sniper attack). The victim or witnesses may be able to answer. (2) Where is the entry wound and where is the exit wound? Over-concern with the entry wound may mean that the exit wound is ignored. (3) What structures may have been damaged between the two? Lungs, major vessels, vascular organs such as liver and kidneys, or bones may be involved. If the trajectory was at an unusual angle, there may be an unusual combination.

Hemodynamically stable patients and patients who stabilized after simple immediate resuscitation were evaluated with a careful evaluation of history and physical examination. A routine x-ray is performed in patients with GSWs. Indication for total body computed tomography (CT) is based on the presence of signs and symptoms of vascular damage at clinical examination. Patients who come are immediately transferred to the operating room for surgery if more serious injuries that require immediate surgical are not diagnosed or homeostasis may be preliminarily reached the emergency room. Hemodynamically stable patients with a no history and clinical examination showing suspected vascular damage are allowed in the radiology department for obtaining a total body CT scan with IV contrast medium and, if surgery is not necessary then they are transferred to the surgical ward trauma for observation. After 24 hours without complications, the patient can be discharged.

Torso Injuries

The torso is defined surgically by 5 anatomical regions to localize penetration sites and includes the thoracoabdominal region, abdomen, flank, back, and pelvis. The thoracoabdominal region is defined by the internipple line superiorly and costal margin inferiorly extending posteriorly up to the inferior tip of the scapula. The abdomen is defined by the costal margin superiorly, anterior axillary lines laterally, and inguinal ligaments and symphysis pubis inferiorly. The flank is defined by the costal margin superiorly, anterior and posterior axillary lines laterally, and iliac crest inferiorly. The interscapular line, between the inferior scapular tips superiorly and the iliac crests inferiorly, defines the back. The pelvis is defined as extending inferiorly from the inguinal ligaments and iliac crests through the upper third of the thigh inferiorly.[13]

Abdominal Pelvic Injuries

The abdominopelvic region has been considered as one of the most vulnerable regions of the body, and injuries involving this area of the body are very serious.[14,15] As the abdominopelvic