Injury, Int. J. Care Injured 46 (2015) 1186–1196

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Review

Firearms, bullets, and wound ballistics: An imaging primer

Tarek N. Hanna [a,*], Waqas Shuaib [a], Tatiana Han [c], Ajeet Mehta [b], Faisal Khosa [a,1]

[a] Division of Emergency Radiology, Department of Radiology and Imaging Sciences, Emory University School of Medicine, Atlanta, GA, United States
[b] Department of Radiology and Imaging Sciences, Emory University School of Medicine, Atlanta, GA, United States
[c] Department of Radiation Oncology, Emory University School of Medicine, Atlanta, GA, United States

ARTICLE INFO

Article history:
Accepted 23 January 2015

Keywords:
Gunshot wounds
Projectiles
Ballistics
Firearms
Radiology
Emergency department

ABSTRACT

Based on its intrinsic mass and velocity, a bullet has an upper limit of wounding potential. Actual wound severity is a function of the bullet construction and trajectory, as well as the properties of the tissues traversed. Interpreting physicians must evaluate the bullet trajectory and describe patterns of injury resulting from the effect of energy transfer from the projectile into living tissue. A basic understanding of firearms, projectiles, and wound ballistics can help the interpreting physicians in conceptualizing these injuries and interpreting these cases.

Contents

Introduction

Gunshot wounds (GSW) resulted in 73,505 emergency department (ED) visits in the United States in 2010, and are the second leading cause of injury death after motor vehicle crashes [1]. Clinically stable patients nearly always undergo some form of diagnostic imaging, and radiologic evaluation is central to patient management. A basic knowledge of projectiles (bullets) and the interaction of ballistics with living tissue can aid the interpreting physician in understanding the wound patterns created by gunshot injuries. In our review we will cover basic principles of firearms and ballistics, introduce the subject of wound ballistics from a radiologic perspective, and provide interpretative pearls related to the diagnostic imaging of GSWs.

Firearms and ballistics

The majority of ballistic injuries within the civilian population are inflicted by handguns, rifles, and shotguns [2]. The resulting

* Corresponding author at: Division of Emergency Radiology, Department of Radiology and Imaging Sciences, Emory University Midtown Hospital, 550 Peachtree Road, Atlanta, GA 30308, United States. Tel.: +1 404 686 5612; fax: +1 404 686 5709.
E-mail addresses: tarek.hanna@emory.edu (T.N. Hanna), Waqas.shuaib@emory.edu (W. Shuaib).

[1] *Disclosure*: Faisal Khosa is the American Roentgen Ray Society Scholar (2013–2015).

http://dx.doi.org/10.1016/j.injury.2015.01.034
0020–1383/

projectiles should be conceptualized as "low-energy" or "high-energy" [2]. This refers to the kinetic energy (KE) of the projectile, which is equal to one-half the mass times velocity squared ($KE = \frac{1}{2}mv^2$). This KE establishes the upper bound of potential tissue destruction, which would occur if all the KE of the projectile was transferred directly into causing tissue damage. In practice, some of this kinetic energy is lost as heat. Furthermore, if the bullet exits the body, only a fraction of the total energy is deposited in living tissue. Each bullet has its intrinsic mass, but the initial velocity is largely a function of the firearm. Due to short barrel length, handguns produce a low-velocity projectile that usually deposits all of its kinetic energy within the target, thus creating an entry but no exit wound. Rifles have longer barrel lengths that produce a high velocity, high-energy projectile. Shotguns also have long barrels and fire a single bullet or multiple pellets at relatively low velocity with each individual low mass pellet having low energy; however, their multiplicity can cause significant damage, as the wounding potential is based on the combined energy from all pellets. All firearms except shotguns have rifled barrels. Rifling is indicated by circular grooves lining the bore—or internal surface—of the barrel. These grooves allow the projectile to spin and provide stability during flight [3].

Bullet characteristics and construction

The basic unit of firearm ammunition is known as the round. Each round contains a primer, casing, propellant, and projectile (Fig. 1). The primer ignites the propellant surrounded within the casing, which acts as an accelerant that propels the projectile. The projectile is released from the round upon firing and strikes the target [3]. In this review, bullet is synonymous with projectile.

Calibre refers to the bullet diameter in hundredths of an inch and is independent of mass, velocity, and construction [4]. Most bullets are typically made of lead and may or may not be surrounded by a metal jacket. Civilian bullets typically have hollow or soft points, which weaken the projectile and result in an expanded or mushroomed tip at impact. Hollow points have a hole within the jacket of the bullet tip. Soft points are not covered by a metal jacket, and the metal core of the bullet at the tip is exposed [2]. As a result of the Hague Convention of 1899, military bullets designed to expand are prohibited and are therefore covered by a metal jacket and do not deform [5]. Unlike handgun and rifle ammunition, shotgun rounds either consist of a large, single projectile or multiple pellets encased within a shell [2].

Wound ballistics

Wound ballistics is a term used as a subset of terminal ballistics, referring to the effects of projectiles (bullets) on living tissues. The disruptive forces of these bullets and the retentive capabilities of the tissues influence these effects, which in essence form the projectile–tissue interface. The understanding of this phenomenon is important for the interpreting radiologist as it determines the trajectory, terminal behaviour of the bullet, and its ultimate wounding effects [6].

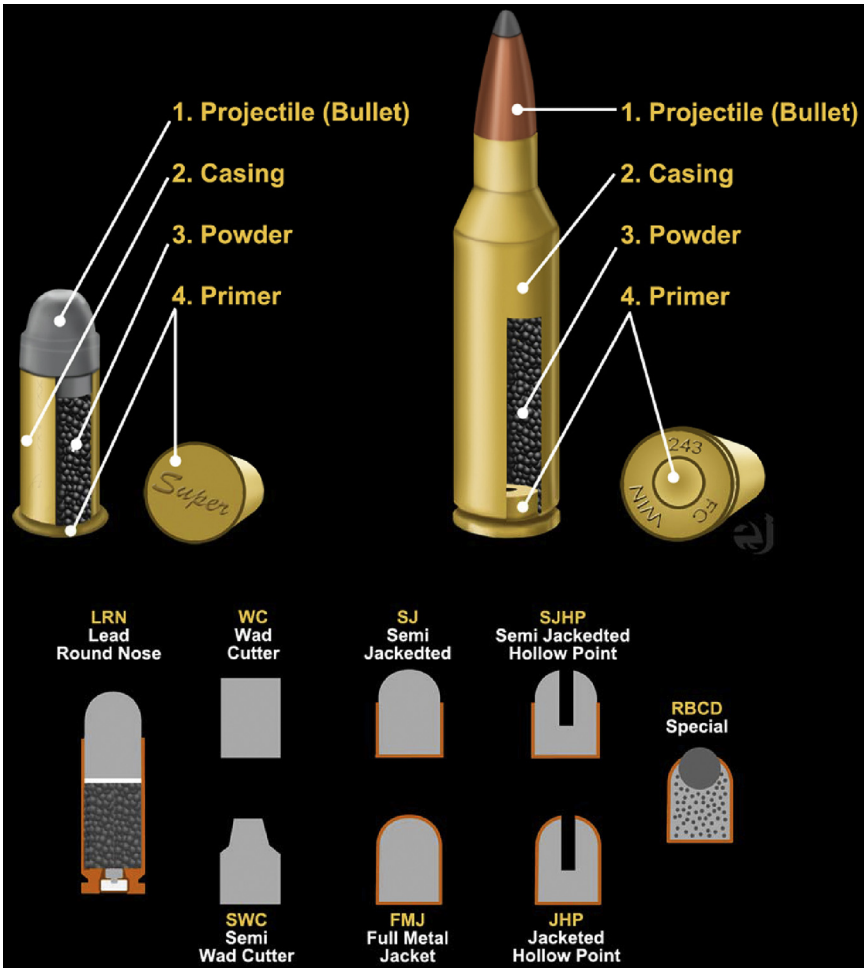

Fig. 1. A diagram of the composition of a round, as well as a graphical illustration of the features of various common bullet types.