6.2. Ureteral Trauma Due to Penetrating Missiles

P.C. Peters, T.C. Bright III, and R.G. Kibbey III

With 9 Figures

A. Incidence

Ureteral injury secondary to penetrating weapons has been described as rare. Fisher et al. (1972), in reviewing the literature in 1971, found 123 ureteral injuries secondary to gunshot wounds, including only 33 reported during World War II. Culp (1947) reported an incidence of ureteral injury as 3.75% out of 160 urogenital injuries during World War II. Holden et al. (1976) reported 63 cases in 1976. Our series is composed of 59 cases of ureteral injury secondary to external violence over a 10-year period (Bright and Peters, 1977). The reasons for infrequent injury are: (1) the ureter is a small tubular organ surrounded by loose retroperitoneal fat and connective tissue which allows great

![Fig. 1. General course of the ureter. Note ureter passing posterior to gonadal vessels and posterior to uterine artery. (Reprinted from Orkin, 1964)](image_url)
mobility; (2) its depth in the retroperitoneal fossa makes it quite inaccessible to any except major injury; (3) it is protected by thick surrounding structures, e.g., the vertebral column medially, the psoas and paraspinal muscles posteriorly and laterally, and the peritoneum with its contents anteriorly. The course of the ureter is depicted in Fig. 1.

B. Etiology

Of the reported cases, the major causes of ureteral injury are: (1) gunshot wound, (2) stab wound, (3) other penetrating missiles (Table 1). Because of the aforementioned anatomic protection, the higher velocity missiles are more apt to cause ureteral injury because of their depth of tissue penetration. Wound damage produced by a penetrating missile is proportional to its mass and velocity or impact. Of these variables, velocity is the most critical as demonstrated by the equation \( KE = MV^2/2 \). Further kinetic energy is imparted by rotational energy derived from the weapon. High-velocity missiles are those \( > 1,000 \) ft/s; low velocity missiles are those \( < 1,000 \) ft/s velocity. The human body cannot stop a high-velocity missile except at great distance. Muzzle velocity is the velocity of the bullet when leaving the gun barrel. Impact velocity is the velocity of the missile when an object is struck. Residual velocity is the velocity retained after the target is traversed. As a high-velocity missile strikes an object, a temporary cavity results from the release of kinetic energy released on impact and during passage of the bullet (DEMUTH, 1969). This temporary cavity results from an explosive phenomenon with stretching of surrounding tissue during missile passage. Damage may thus be done to structures several centimeters away from the true cavity left by the missile, i.e., blast effect. The damaging effect of the bullet is proportional to the specific gravity of the tissue. Lung, therefore, receives only minimal damage. Liver, skin, and muscle receive marked damage and bone receives extreme damage. Blood vessels are an exception, however, because even though they have a low specific gravity, they are damaged by stretching, resulting in intimal disruption and thrombosis.

The shape of the missile determines the decrease in velocity due to traversing the atmosphere and, therefore, the reduction of the muzzle velocity to impact velocity over a given distance. Most bullets are lead alloys (DEMUTH, 1966) with a low melting point. At extremely high velocities \( (> 2,000 \) ft/s), such as with combat weapons, bullets are fully jacketed so they will not melt in the barrel and become distorted. These bullets tend to make a cleaner path through an object and, therefore, retain more residual velocity. Conventional bullets used for hunting, etc., are not fully jacketed, i.e., soft tips, and expand their caliber on impact. They lose more velocity and impart more kinetic energy. They leave a larger cone of damage than the fully jacketed missiles which leave an area of damage which is cylindrical.

The ureteral blood supply is of great importance (Fig. 2) when considering injuries caused by high-velocity missiles. The ureter is supplied by three sets of vessels. The proximal ureter is fed by the hilar and perihilar branches of