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MANAGEMENT OF CIVILIAN GUNSHOT INJURIES TO THE HIP

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Guidelines used today for the management of gunshot wounds to the hip were established at the end of World War I.[2,6,9,15,20,24,25] The treatment course includes early deep wound excision, repeated debridement, and intravenous antibiotic therapy. This treatment protocol was developed from experience with artillery and rifle injuries under battlefield conditions. Under civilian circumstances, physical findings can be subtle, high-velocity gunshot wounds are uncommon, and a wide variety of diagnostic studies are available.[16,19,27] Experience with 53 consecutive injuries at a Los Angeles Trauma Center has led to refinement of the diagnostic evaluation. We present a treatment protocol that has been successful in preventing septic arthritis without the routine use of hip arthrotomy.

IDENTIFICATION OF PATIENTS AT RISK

Joint contamination occurs when a bullet or the fracture caused by the bullet enters the hip capsule (Fig. 1). Hip injuries that did not violate the capsule were not included in this review. Any patient with a bullet wound between the umbilicus and the proximal one third of the thigh is at risk of hip joint penetration. Between September 1986, and January 1994, 53 patients presented to the Martin Luther King, Jr/Charles Drew Medical Center with a gunshot injury to the hip. The entry site was the buttocks in 32, the anterior thigh or inguinal area in 13, the lateral hip in 6, and the lower abdomen in 2 patients.

DIAGNOSIS OF JOINT PENETRATION

History and Physical Examination

The history should include a description of the weapon as a rifle, assault weapon, shotgun, or handgun. Entry wounds created by each may have a similar appearance.[21] The injuries that result from a rifle, assault weapon, or close-range shotgun blast are high-energy and characterized by a deep zone of necrosis. The patient's description of the weapon can alert the physician to the presence of deep, devitalized tissue, before it becomes clinically evident.

When a bullet enters the body, its path is unpredictable. Two separate entry wounds can masquerade as one entry and one exit wound. A bullet deflected by bone can exit in an unexpected location. When a high-velocity bullet strikes cortical bone, fragments of the skeleton become projectiles or secondary missiles leaving several exit wounds. Entry wounds in the

From the Martin Luther King, Jr/Charles Drew Medical Center, Los Angeles, California

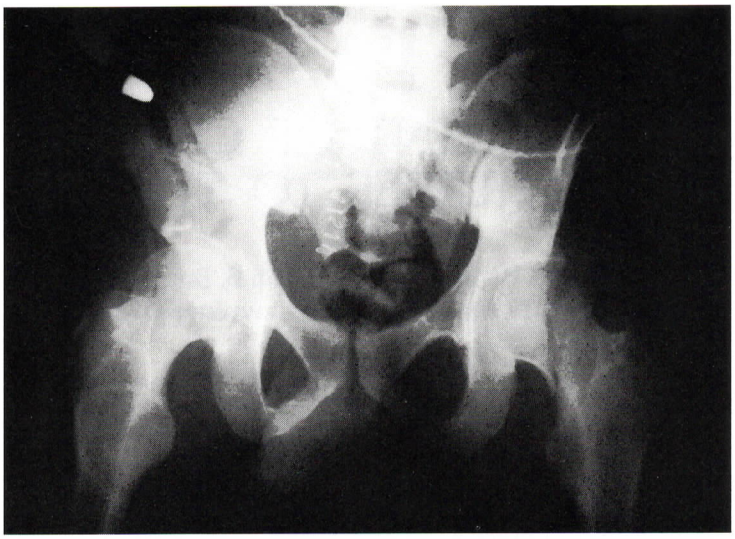

Figure 1. Joint contamination occurs when a bullet or the fracture caused by a bullet enters the joint. On the right, bacteria gain access to the hip by contiguous spread from the bullet through the fracture. The left hip was contaminated when a bullet passed through the joint.

gluteal folds or crease, may be difficult to recognize, yet they carry great potential for morbidity.

Hip penetration is not difficult to detect in an alert, cooperative individual. The patient complains of hip or groin pain that is exacerbated by passive hip motion and log rolling of the leg. A patient that cannot fully cooperate during the clinical evaluation is at risk of having the hip injury overlooked. Seven hip injuries were diagnosed late, 48 hours to 51 days after the injury occurred. In each case, the patient had an altered mental status because of drugs, alcohol, head trauma, or hypovolemic shock. Young children and patients with multiple gunshot wounds are similarly at risk of having a missed injury.

A complete evaluation includes an abdominal and rectal examination. Seventeen percent of the hip injuries were transabdominal. The bullet passed through the abdomen before or after entering the hip. Nineteen transabdominal gunshot wounds to the hip have been reported in literature since 1940.[3–5] Eleven of these (58%) were diagnosed after septic arthritis had destroyed the hip cartilage. Two of nine (22%) transabdominal injuries in this series were diagnosed after the cartilage was destroyed by infection.

Roentgenograph

An anteroposterior roentgenograph of the pelvis is obtained in all patients at risk of having a hip injury. A cross-table lateral projection of the affected hip provides a lateral view of both the femur and the acetabulum. Judet 45° oblique views of the pelvis are useful when an acetabular injury is suspected.[14]

Roentgenographs of a high-energy hip injury are characterized by large air infiltrates extending from the subcutaneous tissues to the deep muscle compartments (Fig. 2). A 7-cm region of fracture comminution or segmental bone loss was present in 6 of the nine patients with a high-energy injury.

Roentgenographs of the 44 low-energy injuries were characterized by a stable cortical defect at the point of bullet impact. Only five low-energy injuries resulted in an unstable fracture. Roentgenographs of 14 low-energy gunshot injuries demonstrated no fractures. In each case the only evidence of joint violation was a bullet overlying the joint on multiple views. The bullet caliber and the type of metal jacket did not affect wound characteristics or injury management.

Detection of Capsule Violation

A fracture of the acetabulum, femoral head, or intracapsular portion of the femoral neck are the best roentgenographic evidence of joint violation. In the absence of a fracture or defect, further studies are indicated to verify joint violation. The capsule can be torn and the joint contaminated in the absence of a fracture.

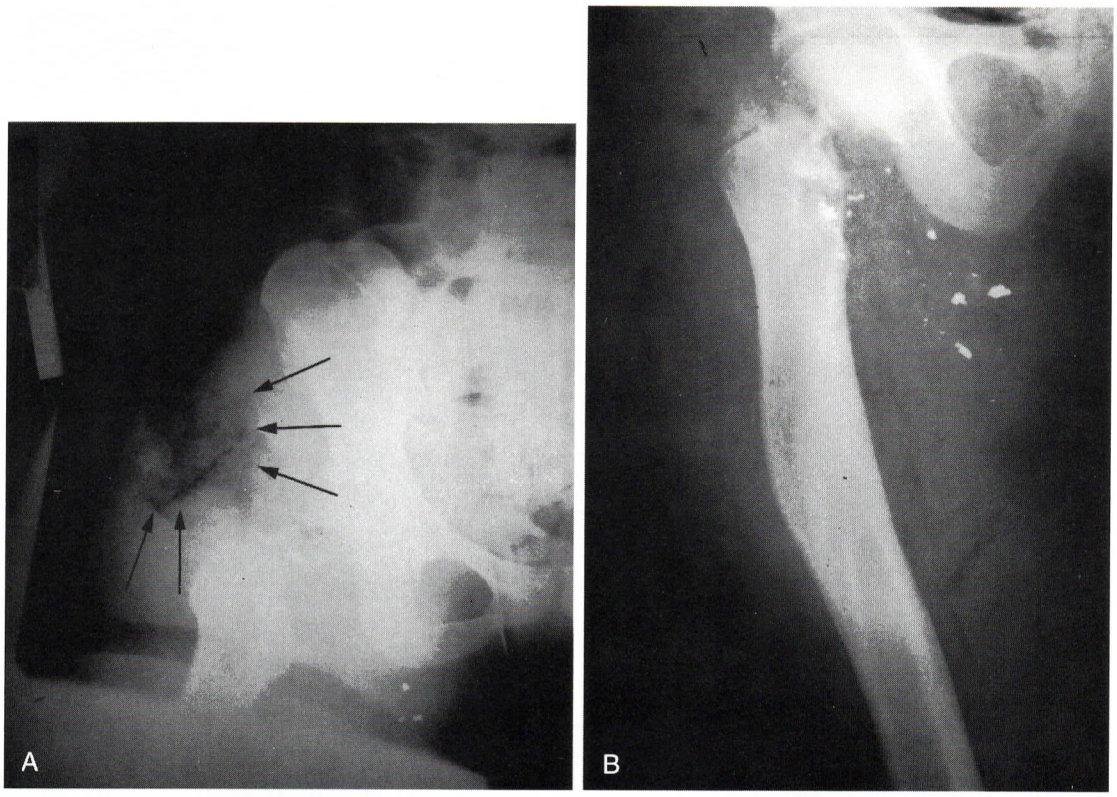

Figure 2. *A*, A high-energy gunshot wound is characterized radiographically by diffuse air infiltration extending from the subcutaneous tissue to the deep muscle compartments. *B*, Segmental bone loss of more than 7 cm was observed in six of the nine patients with a high-energy injury.

When this scenario occurs, the roentgenograph will show a normal hip.

Identification of an Intracapsular Bullet

The best radiographic evidence that a bullet is intracapsular is a fracture of the femoral head or neck with a centrally located bullet on the AP and lateral radiographs. A bullet in the acetabulum can be difficult to localize using radiographs.

To apply radiographic principals to hip geometry and prove that a bullet is intracapsular is complex. Wide variations in radiographic technique occur in the trauma environment. A bullet that appears to be intracapsular on multiple radiographic views may lie outside of the joint (Fig. 3). On two occasions, an arthrotomy was performed on a hip that was not violated. In each case, the bullet was overlying the hip on multiple radiographs, but the bullet remained outside of the joint.

In contrast, it is quite simple to prove that a bullet has come to rest outside of the joint. One roentgenograph showing the bullet outside of the joint proves that the bullet came to rest outside of the joint. Classifying radiographic findings as conclusive or inconclusive (Table 1) assists in determining when further studies are indicated.

ARTHROGRAM

When plain radiographs are inconclusive, a fluoroscopically assisted arthrogram is the most sensitive test to detect joint violation or an intracapsular bullet. In the fluoroscopy suite or the operating room, the hip is scanned to detect a fracture of the femoral head, neck, or acetabulum. If an intracapsular fracture is detected, then permanent radiographs of the hip are taken.

The fracture is evidence that a missile conta-

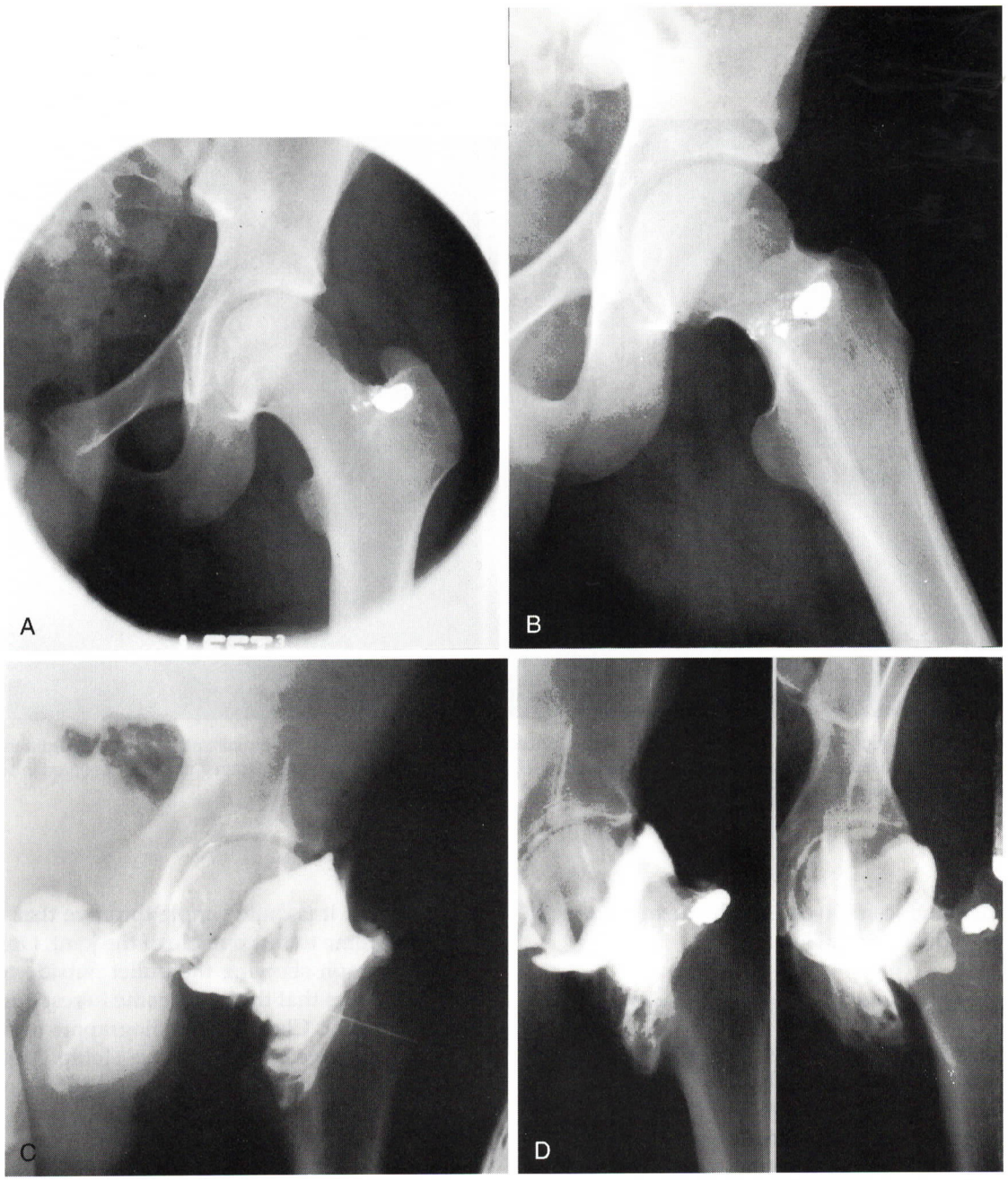

Figure 3. *A*, Anteroposterior radiograph of the hip showing a bullet overlying the femoral neck. No fracture is apparent. *B*, Lateral radiograph similarly shows a bullet overlying the femoral neck but no fracture. *C*, Joint aspiration yielded no blood; however, a single arthrographic view shows a bullet that appears to be surrounded by contrast material. *D*, This view was obtained by rotating the hip through a full range motion. The bullet is clearly extra-articular, and the capsule was never violated.

minated the joint. This suspicion is confirmed by a needle inserted into the joint under fluoroscopic guidance. A hemarthrosis indicates joint violation. The aspirate is sent for cell count, culture, and grain stain. Contrast injected into the capsule documents accurate needle placement. A hole in the capsule or acetabulum results in extravasation of contrast (Fig. 4). A trail of contrast can demonstrate communication between the joint and bowel or bladder.[12,17,22]

Table 1. CLASSIFICATION OF RADIOGRAPHIC FINDINGS TO DETERMINE JOINT VIOLATION OR INTRACAPSULAR BULLET

Findings	Diagnosis	Pitfall
Fracture of the femoral head, intracapsular femoral neck, or acetabulum	Joint violation	
Bullet is extracapsular on any roentgenograph	Bullet outside of hip capsule	
Normal hip	Inconclusive	Capsule can be torn and contaminated in the absence of a fracture
Bullet overlies the hip on multiple projections	Inconclusive	Extracapsular bullets can overlie the hip on multiple projections

Fluoroscopy provides clear evidence that a bullet is in the femoral head or neck but is less useful in demonstrating a bullet in the acetabulum. A missile in the head or neck of the femur will rotate as the bone is rotated. It will overlie the joint in every projection as the hip is taken through a range of motion. On no projection will the bullet appear to be outside the joint. These fluoroscopic findings document that the bullet has come to rest within the joint. The arthrogram will show a missile in contact with or surrounded by contrast.

A bullet that penetrates the acetabulum presents a special diagnostic problem. Lodged in the acetabulum, it will not rotate with the femoral head and neck. Imbedded in subchondral bone, it can appear to be outside of the joint on some projections. The bullet can be out of contact with the articular cartilage but remain in communication with synovial fluid (Fig. 5). Dissolution of the lead will cause systemic lead toxicity and joint destruction.[8,13,23,26]

COMPUTED TOMOGRAPHY SCAN

A computed tomography (CT) scan of the hip is obtained before an arthrotomy to remove a bullet in the acetabulum. By identifying an intra-articular fracture and localizing a bullet, the CT scan provides definitive signs of joint violation and assists in planning the surgical approach.

False-negative studies and artifact limit the usefulness of CT scans. Images taken from cuts above or below the point of bullet impact can miss a fracture or fail to locate the bullet. The CT scan is not sensitive to capsule violation in the absence of a fracture. Joint fluid for cell count, gram stain, and culture is not obtained; an obvious disadvantage when the issue is

Figure 4. Seventeen days after an exploratory laparotomy for multiple gunshot wounds, this 21-year-old complained of hip pain and became septic. Hip aspiration yielded purulent fluid with a white blood cell count of more than 100,000 per cubic millimeter. An arthrogram revealed a narrowed joint space and a recto-acetabular fistula.

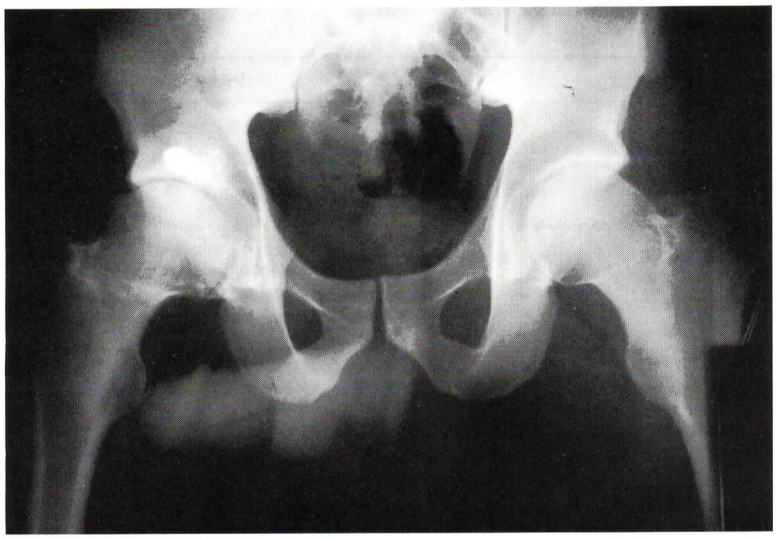

Figure 5. *A*, A bullet lodged in the subchondral bone of the acetabulum can cause lead synovitis and systemic lead toxicity. Seven years after the injury, the bullet remains in contact with synovial fluid, although it is not in direct contact with the articular surface. The patient developed hip stiffness and pain.

joint contamination. Scatter from the metal obscures the adjacent bones, which can hide fractures and make it impossible to determine if a bullet is in the joint.

TREATMENT

Antibiotic Therapy Without Arthrotomy

Our current recommendation for treatment of simple joint violation is a 3-day course of intravenous Ancef (SmithKline Beecham, Philadelphia, Pennsylvania) and gentamicin. Patients are admitted to the hospital for a total of 5 days. This admittance allows 48 hours for gait training, physical therapy, and observation after antibiotics have been discontinued. If clinical signs and symptoms of infection develop, fluoroscopically assisted hip aspiration and arthrogram are performed. If an arthrogram was performed on admission, it is repeated whenever infection is suspected. Fluid analysis that suggests infection is an indication for immediate arthrotomy. Suggestive findings include an elevated white cell count, a positive gram stain, or bacterial growth on culture in a symptomatic patient. Patients treated with antibiotic agents without arthrotomy must fit the following criteria:

1. The injury is caused by a low-energy gunshot
2. The injury is not transabdominal
3. The bullet is not in communication with synovial fluid
4. The stable fracture does not require internal fixation

Of 53 patients, 15 met these criteria and were treated without an arthrotomy. None developed septic arthritis. Six infections occurred in patients initially treated with antibiotics alone. Four of the infections followed a transabdominal hip injury. One had a missed injury with a bullet in synovial fluid and one infection followed a missed, displaced, femoral neck fracture.

Hip Arthrotomy

A hip arthrotomy is performed on every hip with a high-energy injury or transabdominal injury and in conjunction with early internal fixation. Bullets in communication with synovial fluid and intra-articular bone fragments should be removed by an arthrotomy. These fragments can be removed arthroscopically by surgeons experienced with this procedure.[11] We performed one successful bullet extraction using a posterior arthroscopic approach. An algorithm for management with or without arthrotomy is presented in Figure 6.

Internal Fixation

The indications for internal fixation include unstable intra-articular fractures and unstable femoral neck fractures. Each of these injuries

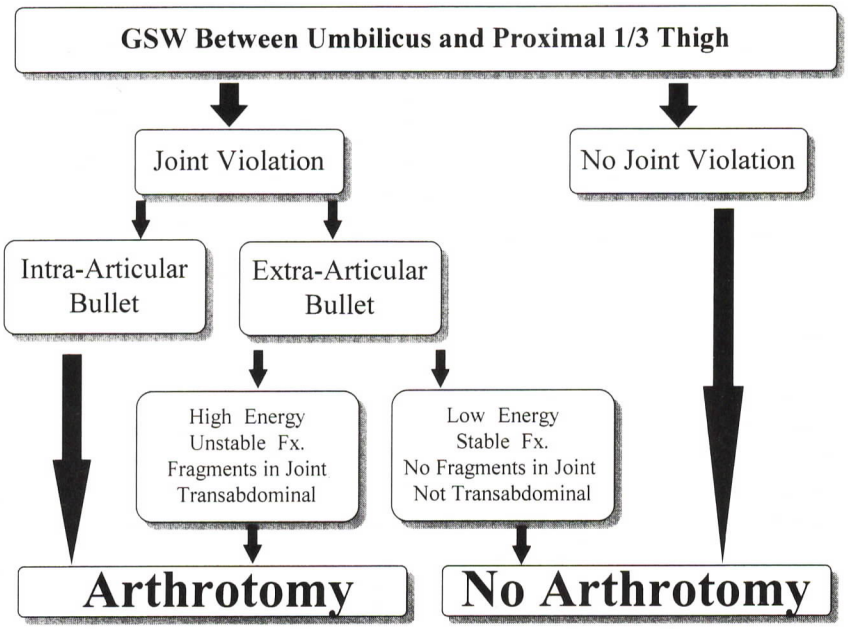

Figure 6. Algorithm for determining the necessity of an arthrotomy.

are fixed at the time of the initial joint debridement. No infections occurred in five patients that had an immediate arthrotomy and internal fixation.

Twenty femoral neck fractures with small cortical defects at the point of bullet impact were treated without surgery. None became displaced.

Arthroplasty and Fusion

We do not recommend hip arthroplasty or arthrodesis in the acute setting. These procedures should be performed as elective procedures after wound healing is complete. Resection arthroplasty may be performed immediately when inadequate bone is available for internal fixation. We performed one immediate resection arthroplasty, one total hip arthroplasty and one hip arthrodesis.

SPECIAL PROBLEMS

Retained Bullets

Surgery is performed on a radiolucent table to facilitate fluoroscopy. A missile that moves before or during an operation may be difficult to find.[1] Twenty arthrotomies were performed for bullet removal. Thirteen posterior bullets were removed using a posterolateral incision. The iliofemoral incision was used to remove two bullets that came to rest in the anterior hip and to remove three bullets in the medial wall of the acetabulum. The ilioinguinal incision was not selected to approach bullets in the quadrilateral plate of the medial wall because it provides inferior access to the capsule for an arthrotomy. The femoral distractor was used in four cases. All bullets were removed without dislocating the hip. No iatrogenic avascular necrosis occurred. One anterior bullet was removed by an iliofemoral approach after a failed attempt to remove it through a posterolateral approach.

Femoral Neck Transection

Each of five patients with a displaced femoral neck fracture had a poor result, despite immediate fracture stabilization. Four had avascular necrosis, nonunion, and head collapse within 18 months of the injury. The fifth patient had continued pain and inability to bear weight for 1 year, despite magnetic res-

onance imaging and a bone scan that showed normal head perfusion.

Despite these poor results, early internal fixation of displaced femoral neck fractures is recommended when bone stock is adequate to achieve stable fixation. The integrity of the blood supply to the femoral head cannot always be determined at the time the patient presents for treatment. If the blood supply to the femoral head remains intact and the fracture unites, a good result is anticipated. Rigid fixation of an avascular head can prevent the soft-tissue contractures and limb shortening that result from a resection arthroplasty. Four patients with displaced neck fractures and avascular necrosis had a good functional result for 1 year before femoral head collapse and nonunion resulted in stiff and painful hips.

Transabdominal Hip Injuries

Late recognition leads to poor results in the treatment of transabdominal hip injuries. In 6 of the 10 transabdominal injuries, the abdominal injury was treated immediately while treatment of the hip injury was delayed more than 48 hours. In those six cases, three bullets entered the contralateral buttocks, two entered the abdomen, and one entered over the ipsilateral greater trochanter.

Seven transabdominal hip injuries had a deep infection. The first two cases of septic arthritis in this series were diagnosed after the cartilage was destroyed. The last five infections had an arthrotomy early enough to preserve the articular cartilage. All large bowel injuries had a colostomy, and small bowel injuries were repaired. An arthrotomy, bullet removal, and a thorough debridement are important in each case to reduce the threat from spilled bacteria, bowel nutrients, and destructive enzymes.

SUMMARY

The orthopedic surgeon at a civilian trauma center is likely to encounter a gunshot injury to the hip. The nonmilitary literature regarding this injury gives few guidelines regarding an appropriate diagnostic evaluation or the indication for arthrotomy. We found that the best diagnostic test to detect joint penetration was hip aspiration followed by an arthrogram. Selected cases can be treated successfully with antibiotic therapy without an arthrotomy. These cases involve a low-velocity missile that passes through the joint, causes minimal bone disruption, and is free of bowel contaminants. If an arthrotomy is not performed, the physician must follow the patient with repeated physical examinations, complete blood counts, and a hip aspiration whenever infection is suspected.

All transabdominal hip injuries require an immediate arthrotomy. In this series, bullets left in contact with joint fluid resulted in joint destruction or infection. Each patient with a displaced femoral neck fracture had a poor outcome with internal fixation. Hip arthroplasty or fusion should be considered as elective procedures for definitive management of these injuries.

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