Maxillofacial Firearm Injuries: A Protocol for Management in Assiut University Hospital

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Abstract

Aim of Study: To evaluate and classify maxillofacial firearm injuries and to develop a practical protocol to improve patient outcomes.

Patients and Results: A total of 179 patients representing about 4.29% of all maxillofacial trauma in the period between 2006 to 2013, with marked increase in the incidence after the Egyptian revolution 25/1/2011, were treated from firearm injuries in Assiut University Hospital. Patients were followed for at least 6 months. Injuries were accidental in seven cases; the remaining injuries resulted from assault. We classified injuries into the following categories: (1) Soft-tissue lacerations with no soft-tissue loss or bone fracture (19 patients); (2) Soft-tissue loss without bone fracture (one patient); (3) Soft-tissue lacerations with bone fracture (146 patients); (4) Soft-tissue lacerations with bone loss (11 patients); and (5) Soft-tissue and bone loss (two patients).

Conclusions: Our treatment protocol prioritizes primary emergency care to save the patient’s life and repairing soft tissues to create a bed for second-stage bone reconstruction, if needed. For residual anatomic and esthetic problems, we recommend a later-stage procedure.

Key Words: Firearm injuries – Maxillofacial Injuries.

Introduction

FIREARM injuries to the maxillofacial region can cause severe morbidity and mortality. These injuries vary in significance from trivial to life threatening, and are some of the more difficult injuries treated by multidisciplinary trauma teams. Multiple critical structures are in close proximity in the maxillofacial region; therefore, damage can occur to multiple organ systems. Additionally, soft-and hard-tissue damage can be extensive, often requiring multiple interventions with limited functional and cosmetic results [1].

The severity of maxillofacial firearm injuries depends on the degree and direction of force in the facial region, the force resistance offered by the facial structures, the point of application of force, the shape and size of the projectile and its kinetic energy at impact, which depends on the distance it traveled [2,3]. The formula for determining kinetic energy is KE = mv², where KE is kinetic energy, m is mass of the projectile, and v is velocity.

Based on this formula, the velocity of a projectile has traditionally been considered far more important than its mass in determining its wounding power. Indeed, guns are often classified according to velocity as low-velocity (<350m/s), medium-velocity (350-600m/s), or high-velocity (>600m/s). Considering a typically sized projectile, a velocity of approximately 50m/s is required to penetrate skin, and a velocity of approximately 65m/s will fracture bone [4].

High-velocity bullets have high kinetic energy at impact creating a transient cavitation space with a small entrance wound and a larger exit wound. This type of perforating injury is usually avulsive and causes considerable damage to soft and hard tissues, with massive comminution of the facial skeleton. Concomitant injuries often include secondary distant fractures, caused by propagation of the shock wave, and avascular necrosis, caused by damage to the intimal lining of blood vessels. Low-velocity missile injuries are completely different, because these projectiles possess only about one-third of the kinetic energy of high-velocity projectiles. Such missiles generally cause penetrating injuries, which lead to multiple fractures and skin lacerations and rarely cause tissue avulsion [5-9].

The primary emergency treatment of ballistic injuries to the face should be carried out in accordance with the Advanced Trauma Life Support (ATLS) recommendations, with airway management and control of bleeding [10]. However, there
is no consensus on management of these cases after initial stabilization; multiple opinions exist concerning the timing, sequence and techniques of surgical treatment. We present the experience-based protocol we use in the treatment of maxillofacial firearm injuries at our medical center in a simple and clear way.

Patients and Methods

Between 2006 and 2013, 179 patients were treated at our institution for firearm injuries. The site of injury, associated injuries, surgical procedure, complications and final outcome of the patients were recorded and discussed.

This work was approved by the Institutional Human Research and Ethics Committee. Written informed consent for surgery and for inclusion in this study was provided by adult patients and by the parent or guardian of patients under 18 years of age.

Diagnostic methods:

Patients underwent clinical examination, plain radiography (panoramic X-ray, oblique films and posterior-anterior plain films), Computed Tomography (CT) and Three-Dimensional (3D) CT.

Pathophysiology:

Patients had variable degrees of systemic health risk, according to their age, severity of trauma, systems affected, time between trauma and initiation of primary care, type of weapon used, facilities available and presence of concomitant chronic disease (e.g. diabetes, hypertension, coronary disease).

Projectile wounds cause multiple local effects, including:

1- Penetration allows the projectile to transmit kinetic energy, producing tissue destruction and laceration along its tract.

2- Permanent cavity formation results from direct tissue disruption and destruction.

3- Temporary cavity formation occurs as the projectile travels through the target tissue.

4- Fragmentation occurs, which may involve the projectile (certain projectiles are designed to fragment) or secondary fragments such as clothing or bone that arise from projectile impact.

5- Contamination occurs through the exit and inlet wounds, as air and foreign materials are sucked into the wounds as a result of negative pressure within the cavity.

6- Augmentation of the effect of the primary missiles occurs as bone and tooth fragments function as secondary missiles.

Treatment protocol:

Our protocol has three phases:

Phase I: Primary lifesaving procedures, according to ATLS protocols:

- Airway: Maintain patent airway with suction and/or nasopharyngeal tube, nasotracheal tube, cricothyroidotomy or tracheostomy.

- Bleeding: Control accessible bleeding with direct pressure and packing for hemostasis.

- Cervical collar.

- Intravenous line and hemodynamic stabilization.

- Thorough clinical systematic examination, prioritizing:
  - Vascular injuries.
  - CNS injuries.
  - Abdominal injuries.
  - Compound fractures.

- Imaging: Radiological investigations after patient stabilization (cervical spine, panoramic view, skull, chest, CT, 3D CT).

- Supportive treatment (anti-tetanic, antibiotic, analgesics and a single injection of corticosteroid).

- Medical and medico-legal records.

Phase II: Surgical procedures:

1- Soft tissue:

- Tissue preservation: Meticulous primary closure of intraoral and extraoral soft tissues to provide full coverage of bone and fractures.

- Local flaps for soft tissue repair.

2- Bone:

- Conservative debridement of bone fragments.

- Restoration and stabilization of occlusal relations via closed reduction and intermaxillary fixation (with minimal use of transosseous wire, plates and screws).

- Reconstruction of bone defects using bone grafts (calvarial, rib, iliac crest or vascularized free grafts) during the first weeks following trauma.

3- Broken teeth and remaining roots: Avoid removal if this would require excessive manipulation and periosteal stripping.

4- Foreign bodies: If accessible, remove; if inaccessible, leave them.

5- Drain the maxillary sinus with a Foley catheter.
6- Facial nerve: No immediate facial nerve graft in avulsive wounds, because mostly muscle and nerve has been destroyed.

7- Safe post-operative airway: Temporary tracheostomy can be performed, if not done before surgery, in case of:
   - Avulsive wounds of the lower and middle thirds of the face.
   - CNS injury.
   - Laceration of the tongue or soft palate.
   - Hematoma or edema in the neck.
   - Laryngeal injury or edema.
   - Retained bullet behind the nasopharynx.

Phase III: Reconstruction of bone defect and correction of any remaining deformity:

Any bone defect can be reconstructed at a later stage, depending on the general condition of the patient and local condition of the tissues. Reconstruction usually occurs within 6 months, using iliac bone, rib, calvarial or microvascular bone graft or distraction osteogenesis.

Results

Between 2006 and 2013, a total of 179 patients were treated for maxillofacial firearm injuries at our institution, representing 4.29% of all maxillofacial trauma cases (Table 1). Patients were followed for at least 6 months. There were 151 male and 28 female patients, with ages ranging from 5 to 68 years (Table 2). The injuries were accidental in seven cases; the remaining injuries resulted from assault. Airway patency was ensured with immediate tracheostomy in the ER in nine patients and naso-pharyngeal intubation in 13 patients; in the remaining cases, positioning and suction were used. In 28 patients tracheostomy was performed at the conclusion of surgery to ensure a safe post-operative airway.

Table (1): Percentage of maxillofacial firearm injuries among total number of maxillofacial trauma cases.

<table>
<thead>
<tr>
<th>Year</th>
<th>Maxillofacial trauma</th>
<th>Maxillofacial firearm injuries</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>467</td>
<td>7</td>
<td>1.5</td>
</tr>
<tr>
<td>2007</td>
<td>453</td>
<td>9</td>
<td>1.9</td>
</tr>
<tr>
<td>2008</td>
<td>512</td>
<td>6</td>
<td>1.17</td>
</tr>
<tr>
<td>2009</td>
<td>493</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>2010</td>
<td>443</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>2011</td>
<td>590</td>
<td>28</td>
<td>4.74</td>
</tr>
<tr>
<td>2012</td>
<td>579</td>
<td>40</td>
<td>6.7</td>
</tr>
<tr>
<td>2013</td>
<td>609</td>
<td>56</td>
<td>9.19</td>
</tr>
<tr>
<td>Total</td>
<td>4164</td>
<td>179</td>
<td>4.29</td>
</tr>
</tbody>
</table>

All patients had soft-tissue injury with or without bone injury in the facial region. Injuries were classified into the following categories:
   - Soft-tissue laceration, intraoral or extraoral, with no soft-tissue loss or bone fracture (19 patients).
   - Soft-tissue loss with no bone fracture (one patient).
   - Soft-tissue laceration with bone fracture (146 patients). The most commonly affected sites were the mandible (62 cases), maxilla (28 cases), zygomatic region (21 cases), nose (one case) and frontal bone (one case). In 20 patients, more than one site was injured.
   - Soft-tissue laceration with bone loss (11 patients).
   - Soft-tissue and bone loss (two patients).

Our principles for soft tissue reconstruction were in accordance with the reconstructive ladder, including primary repair in most cases (165 patients), local flaps in seven patients, skin grafts in one patient and regional flaps in three patients, depending on the extent of damage.

Our principle for bone reconstruction was to restore shape, contour and occlusion using closed reduction with intermaxillary fixation, with minimal use of interosseous wiring, plates and screws. Thirteen cases had bone loss (three in the maxilla, nine in the mandible and one in the nose). The three cases with maxillary bone loss refused further reconstructive surgery. The remaining 10 cases were reconstructed within 6 months after the primary surgery, six with iliac bone grafts, three with rib grafts and one with an external distractor in a patient with mandibular bone loss.

Associated injuries:

Associated injuries included ocular injuries in 13 patients, abdominal injuries in two, limb injuries in six, chest injuries in seven, CNS injuries in five, otorrhea in seven and cervical spine injuries in three.
Outcomes:

Five patients died, three in the ER before surgery due to polytrauma and two post-operatively owing to deterioration of consciousness.

Complications:

Complications included superficial wound infection in nine cases and fluid collection requiring drainage in two cases. Infections were controlled with antibiotics based on culture and sensitivity in seven cases; two patients required removal of plates and interosseous wires. Mouth deviation occurred in four cases and malocclusion in five cases.
Fig. (3): Male patient, 54 years of age. (A) Post-traumatic photograph showing the inlet below the left nostril. (B) X-ray showing the retained bullet. (C) Location of the bullet as seen on X-ray. (D) Intra-operative photograph showing bullet during removal. (E) Bullet after removal. (F) Follow-up clinical photograph.

Fig. (4): Male patient, 17 years of age. (A) Immediate post-traumatic photograph showing the injury. (B) Ten days after injury: Clinical photograph showing ischemia of the skin of the lower eyelid and upper part of the left cheek. (C) Clinical photograph after debridement. (D) Expansion of the frontal skin 4 months after injury. (E,F) Intra-operative photos showing elevation of flaps and reconstruction of the eyelid. (G) Follow-up photograph showing acceptable results.