Chapter 60: Trauma

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Salivary gland injuries are serious and are frequently associated with long-term morbidity. Unfortunately, they are often overlooked or underestimated in patients who have suffered multiple trauma. Thorough assessment and proper management of these injuries can prevent costly and unpleasant sequelae because acute treatment is usually much less difficult than late management.

Because physicians from a variety of disciplines - otolaryngology, plastic surgery, general surgery, neurosurgery, and oral surgery - treat salivary gland injuries, a variety of perspectives and recommendations have developed. Since a single physician is not likely to encounter a large number of patients with salivary gland injuries, many divergent views exist on the optimal principles of their management.

Salivary gland trauma is classified as acute (blunt, lacerating, avulsion, and blast injuries) or chronic trauma (inflammatory changes produced by irritation from dentures, foreign bodies, stones, or irradiation). Therapeutic recommendations vary according to such factors as the mechanism of injury, site of injury, degree of contamination, associated injuries, and general medical status of the patient. To achieve the optimal outcome, the injury must be recognized early, accurately evaluated, and appropriately managed.

Anatomic Considerations

Salivary gland trauma is often associated with injuries involving the overlying skin, the teeth, the tongue, or the oral cavity mucosa. Associated fractures of adjacent skeletal structures such as the zygoma, the maxilla, and the mandible may exist. Lacerations involving the muscles of facial expression or mastication may also exist.

The primary focus of this chapter is on injuries involving the parenchyma of the parotid and submandibular salivary glands, with emphasis on the principles of surgical repair of Stensen's duct, Wharton's duct, and the facial nerve (Fig. 60-1). Particularly important in salivary gland trauma are injuries involving laceration or segmental loss of the facial nerve.

Types of Injury

Salivary gland injuries are classified according to the mechanism, location, and nature of the injuring force. Thus they may be described as primarily external, intraoral, or combined. When the nature of the injury is employed in the classification of patients, acute salivary gland injuries may be classified as lacerations, blasts (particularly shotgun wounds), avulsion injuries (especially human and animal bites) and blunt injuries (in which the tissue sustains compression with or without a tear of the salivary duct or adjacent neural structures). Such compression injuries are often associated with extensive hematoma formation. High-pressure injection injuries are a special class of blunt trauma, which is dealt with later.

Chronic trauma may come from an ill-fitting, irritating denture or an irregular tooth that irritates the ductal orifice. Other etiologic factors in chronic trauma are foreign bodies in the ducts (usually vegetable matter), salivary calculus, and external irradiation.

Examination and Evaluation

Thorough inspection of the injury site with anticipation of potential injuries is the cornerstone of diagnosis and evaluation. The physician must assess the status of the regional skin and oral mucosa, the tongue, and dental structures. He must make a careful search for fractures of adjacent osseous skeletal structures, with initial emphasis on the physical examination and reliance on radiographic studies for confirmation and detail. The muscles of facial expression and mastication should be inspected for laceration or tissue loss. The salivary gland parenchyma is inspected for evidence of injury, usually signaled by the presence of saliva in the wound. The most critical steps involve the evaluation of the salivary gland ducts (Stensen's duct and Wharton's duct) for evidence of laceration or transection. Function testing of the facial nerve and its branches and of the lingual and hypoglossal nerves is performed in every patient (Fig. 60-1).

Laceration of the salivary ducts usually results in the presence of saliva in the wound. If the physician is in doubt, cannulation of the duct through the natural orifice with a lacrimal probe or plastic catheter permits visualization in the wound. Also, sialography can be used to confirm the integrity of the ductal system. Some physicians recommend the injection of a small amount of methylene blue dye, which, if used, should be injected very slowly and in small amounts; this prevents excessive staining of the wound, which would make the repair more difficult.

Assessment of facial nerve function includes attention to the areas of peripheral innervation - the forehead, eyes, nose, and mouth. Each area should be evaluated separately, and the patient should be asked to smile, show the teeth, pucker the lips, and blow. Sensation and motor function of the tongue should be assessed. In the case of nerve transection the distal portion of the nerve should be identified with an electrical stimulator. The proximal portion of the facial nerve or one of its branches may be difficult and require identification of the main trunk as the initial step, with each branch being followed peripherally.

The initial examiner should record all details of the injury, including the time of occurrence and the exact nature of the injuring force. Assessing the degree of contamination is vital to the prevention of postoperative complications. The wound must be inspected meticulously for any foreign material to be removed at this stage.

Penetrating wounds of the neck may result in salivary gland injuries. The parotid salivary glands are located in the "high" region, and the submandibular glands are in the "middle" region in Roon's classification system (Roon and Christensen, 1979) (Fig. 60-2). The parotid and submandibular glands, the facial nerve, and the hypoglossal nerve may be injured, particularly in the case of knife stab wounds and gunshot wounds (Fig. 60-3).

Facial trauma involving forces sufficient to cause facial bone fractures may result in associated salivary gland injuries. There are reports of maxillary fractures with lacerations of Stensen's duct that have healed in a manner that produced a parotid-antral fistula. Clinically, these patients experience prandial rhinorrhea, which can be relieved by surgical transposition of Stensen's duct or closure of the parotid-antral fistula (Bergstrom and Hemenway, 1971; Scher and Poe, 1988).

Penetrating Wounds

Shotgun wounds

Injuries inflicted by shotguns produce a special situation. First, the mortality following shotgun wounds is twice that following other gunshot wounds. Second, the classification system by Sherman and Parrish (1963) and later May et al (1973) places great emphasis on the distance between the gun muzzle and the victim. The size of the shotgun pellets and the amount of wadding present in the wounds are major factors in determining the complexity of the repair and recovery, but the muzzle-to-victim range is the most significant key to the severity of the wound and the prognosis for recovery.

Superficial, or group A (May)/type I (Sherman), wounds involve penetration only of the skin and subcutaneous tissue. The primary danger is to the facial nerve or eye. Principles for treating this group of injuries are hospitalization of the patient for observation, administration of antibiotics (usually penicillin and one other broad-spectrum antibiotic), adequate tetanus prophylaxis, and careful assessment for any possible associated injuries.

Shotgun wounds, however, are usually complex and often require a team effort. Massive wounds, those described as group B (May)/type 3 (Sherman), are frequently associated with injuries of the central nervous system and facial bone fractures. May observed a 100% infection rate in these individuals; 40% require immediate tracheotomy and most had significant blood loss volume requiring management of hypovolemic shock. All patients with massive shotgun wounds require operative management at some point, but complex closures or flaps should be avoided initially. Wounds caused by shotguns less than 6 meters away have foreign body particles of wadding, massive tissue loss, and bone or vessel injury. Establishing a secure airway and controlling hemorrhage are the first priorities. Meticulous removal of shot and wadding in the operating room and stabilization of skeletal injuries are the next priority. Repair or reconstruction of injured facial nerves should not be attempted in these patients. Identification of facial nerve remnants and tagging with a wire ligature is advised. Cosmetic and functional reconstruction usually requires numerous secondary procedures. These injuries are associated with a high percentage of late complicagtions, including the development of traumatic aneurysms and arteriovenous fistulas. Secondary nerve grafts, bone grafts, and soft-tissue reconstruction may require months to years before the final result is attained.

Recently, a new classification system for parotid gland injury has been proposed on the basis of the results of sialography. As shown in the box, the radiographic indings are grouped according to severity and the distinction that can be made between glandular and ductal injury as observed by Parekh et al (1989). Interestingly, most of the patients treated very conservatively (minimal oral intake and no surgical intervention) did as well as those who had surgical exploration and ductal repair. One advantage of the conservative approach is that the potential for inadvertent injury to the facial nerve during surgical exploration is avoided. The disadvantage of conservative management is that parotid salivary function is not preserved, as scarring results in ductal obstruction and subsequent shutdown of saliva production. It was also noted that the final stages of healing occurred more slowly in those patients with complete ductal transection. This study suggests that conservative therapy is an acceptable treatment option for parotid fistulae.

Human and animal bites

Approximately 600.000 animal bite injuries are estimated to occur in the USA each year (Mathog et al, 1977). About 8% of these involve the head and neck region. Typically, the bite involves a child between the ages of 1 and 10 (75%), the animal is a family pet or known neighborhood dog, and teasing has provoked the bite. The wound itself is usually a crescent-shaped tear, and deep penetration and a degree of tissue crushing may characterize it. Human bites are associated with more virulent complicating infections.

Management issues include the evaluation of the animal as a step in preventing rabies. If one suspects that the captured animal is rabid, fluorescent antibody testing for rabies is indicated. The need for rabies immunization is lower in communities with good animal immunization programs and may be required only if the attack was unprovoked and inflicted by a wild animal. Rabies is prevented by administration of antiserum initially (40 IU of equine antirabies serum); if the animal develops evidence of rabies, the patient must receive the full series of 21 injections followed by 2 booster doses. Prophylactic antibiotics and tetanus prophylaxis are not routine in uncomplicated animal bites.

Chronic Salivary Gland Injury from Foreign Bodies

A foregin body can enter the orifice of Stensen's duct or Wharton's duct and become lodged within the duct for a long period of time. The exact incidence of this phenomenon is not known, and many patients may have spontaneous resolution of these problems. About 50 cases of salivary duct foreign bodies have been reported during the past century. Usually the foreign bodies have been of vegetable origin, with various types of grass seeds being seen most frequently. One result is that the foreign body may produce irritation and some degree of chronic, recurrent sialadenitis on the basis of obstruction and secondary infection. The foreign body may serve as the nidus for development of a calculus within the duct. In the worst cases, abscess formation, a chronic draining sinus, or tumor formation may result in pathologic changes within the gland, requiring excision of the gland.

Salivary Gland Injury Secondary to Irradiation

Radiation therapy injures tissue and impairs function of the salivary glands. When the parotid glands or submandibular salivary glands are included in the irradiation field, xerostomia, or dry mouth, is a sequela. After 1000 rad, the saliva becomes viscous and adherent to tissues and loses its lubricating properties because of the loss of serous secretory activity caused by damage of the secretory organelles and other cellular structures. If portions of a salivary gland are spared the full dosage, potential exists or hyperplasia of the residual secretory cell population, and the symptoms may diminish after 6 to 12 months. Observation shows that the degree of xerostomia is less if the patient receives radiation therapy in a split course with a 2- to 3-week rest period in the middle.

External irradiation appears to be carcinogenic. Modan et al (1974) reported the potential for malignant neoplasms to arise as a late sequela of radiation therapy. They observed a higher frequency of salivary gland tumors in children who had been irradiated for nonmalignant conditions. Saenger et al (1960) noted that irradiation of the thymus during childhood was associated with subsequent thyroid carcinoma one hundred times more frequently than would be expected in the general population and observed parotid and submaxillary gland malignancy in the series as well. Epidemiologic studies have shown that salivary gland tumors, both benign and malignant, are seen much more frequently than would be expected among the survivors of the atomic bomb blast in Hiroshima (Takeichi et al, 1983).

Soft-Tissue Injury and Repair

Many series report that lacerations involving the cheek region are the most frequent facial injury. Fortunately, most of these are minor, and the basic principles of wound repair are uncomplicated. Meticulous cleansing and antiseptic technique, removal of any foreign material, minimal debridement, gentle tissue handling, adequate hemostasis, and simple approximating sutures or adhesive dressings lead to a favorable cosmetic outcome.

Blunt trauma may cause various hidden injuries. A blow to the cheek may tear the wall of Stensen's duct and produce a salivary pseudocyst, resulting in a localized swelling that recurs after aspiration. Repeated aspiration and pressure dressings usually provide adequate supportive treatment during the healing period. Blunt trauma from a high-energy blow may cause severe compression injury of the soft tissue of the parotid. Shetty (1974) studied the effects of blunt trauma on the parotid gland and found a residual salivary gland dysfunction in 80% of these patients. Most had sustained facial bone fractures, and he documented the association of blunt trauma with pathologic dysfunction that was evident on radiographic observation of the filling patterns of the parotid salivary ductal system.

Compression injury to the parotid region has been reported as a consequence of birth trauma from delivery forceps. This possibility, along with hemangioma and other possibilities, should be kept in mind for the differential diagnosis of a parotid mass in a neonate.

Chronic blunt trauma to the orifices of Stensen's duct or Wharton's duct may result from ill-fitting dentures or dental appliances or from dental irregularities. These conditions can lead to inflammation of the duct orifice, producing obstruction and painful swelling of the salivary gland. This problem usually responds to correction of the offending source but severe stenosis may require sequential dilatation or a surgical approach.

Salivary Duct Laceration

Most salivary gland injuries are seen in association with penetrating wounds of the cheek; fortunately, relatively few of these facial lacerations are associated with a serious injury to the salivary duct system or the facial nerve. Of all salivary duct lacerations, those involving Stensen's duct are the most common and pose the most serious problems. Lacerations of ductal structures other than Stensen's duct rarely cause problems. There is usually a temporary saliva leakage, which ceases when healing is complete. Lacerations involving Stensen's duct should be repaired when they are diagnosed or detected; otherwise, the probability of salivary fistula development is high.

Historically surgeons have been quite interested in the problem of salivary duct fistula; over the past century a number of ingenious procedures have been reported. A century ago Kaufman (1883) described intraoral cannulization of Stensen's duct. Nicoladoni (1896) and others just after the turn of the century described transplantation of the distal end of a chronic, cutaneous salivary fistula into the oral cavity. Leriche (1914) recommended avulsion of the auriculotemporal nerve to diminish salivary flow. In 1917 Morestin suggested ligation of the proximal portion of the duct to stop salivary flow and atrophy of the gland. Nicoladoni (1896) and Payr (1922) described end-to-end anastomosis of the lacerated duct. In 1971 Kitamura and Togawa described intraoral fistulization and extraoral ductal surgery as two methods of managing late stenosis of the duct.

Stensen's duct is divided into the glandular portion, the proximal (masseteric) portion, and a distal (buccal) portion. Abramson (1973) recommends treating lacerations of the masseteric portion of the duct by repair and reanastomosis and managing laceration or transection of the duct's buccinator portion by rerouting the proximal portion intraorally.

Many of the principles of management are controversial. Authors vary in their emphasis on what is important and what is nonessential in dealing with these problems. General agreement appears to exist or the following management principle:

1. Magnification with operating loupes or an operating microscope during wound exploration is valuable.

2. Cannulation of the duct through the orifice and passing of a small catheter into the wound isolates the distal segment of a transected duct.

3. Pressing on the gland to express saliva into the wound identifies the proximal portion of the duct.

4. Ductal lacerations should be repaired as early as feasible.

5. Ductal laceration should be suspected if weakness of the upper lip on puckering is associated with a laceration of the cheek.

6. Stensen's duct is located on a line drawn from the tragus to the midpoint between the upper lip margin and the columella (Fig. 60-4).

7. The duct is usually located just inferior to a small accompanying artery and just superior to a small accompanying branch of the facial nerve (Fig. 60-5).

8. Duct laceration should be suspected in all cheek wounds located lateral to a vertical line from the pupil and inferior to a line drawn horizontally at the level of the tragus.

Performing a suture repair of a duct laceration over a small stent is preferable. Many points of nonagreement have been raised regarding the specifics of duct laceration repair. For example, different authors recommend cannulation of Stensen's duct, employing any of the following:

1. 16-, 18-, or 20-gauge Silastic catheter or intracatheter

2. No. 90 polyethylene tubing

3. No. 5 or No. 6 catheter

4. Large nylon sutures.

Disagreement arises regarding whether or not the surgeon should bevel the ends of the duct before reanastomosis. Those who favor beveling suggest that it provides a larger circumference for repair and lessens the degree of postrepair stenosis. Those who suggest that beveling is unnecessary say that it may in fact introduce additional tension on the closure.

The wide variety of preference for suture material may lead on to infer that almost any reasonable suture material is acceptable. Preferences have been reported for all of the following:

1. 5-0, 6-0, 7-0, or 8-0 silk

2. 5-0 or 6-0 polyglycolic acid or chromic sutures

3. 9-0 "sutures"

4. 6-0 to 8-0 nylon

5. 6-0 catgut

6. 7-0 Tevdek

7. No suture at all, just a stent and a pressure dressing.

The duration of time for the retention of the intraluminal catheter is apparently also a matter of preference. Reports have documented good results when the catheter is left in place for time periods ranging from 2 to 14 days.

Authors offer a variety of suggestions for fixation of the ductal splint. Some favor either suturing the splint to the oral mucosa, taping the splint to the face, or both suturing and taping. Abramson (1973) describes passing the splint out through the parenchyma of the gland and through the skin, using a straight needle so that it does not protrude into the mouth (Fig. 60-6).

When the region of the orifice of Stensen's duct or Wharton's duct has sustained significant injury, the best management appears to be a surgical rerouting of the remaining duct through the buccal mucosa and creation o a "fish mouth" opening, in anticipation of some stenosis during healing. A Silastic catheter should be left in place in the duct for 10 to 14 days.

Failure to manage laceration and transection of the salivary ducts properly in the initial phase appears to be a factor in late stenosis of the duct. Evaluation of patients who developed symptomatic ductal stenosis requires sialography. Mild obstruction or stenosis may respond to repeated dilatation, with an excellent outcome. Severe stenosis may require a secondary surgical repair or a ligation of the duct.

Facial Nerve Injury

The otolaryngologist has been identified as "the keeper of the facial nerve". Our scientific literature is replete with descriptions and opinions concerning the management of facial nerve injuries, noting that trauma is the second leading cause of facial paralysis and that penetrating trauma and injury to the nerve is the most common cause of extratemporal facial paralysis. This section reviews some of the basic concepts and controversies concerning the evaluation and management of facial nerve injuries.

Basic science

Transection of the facial nerve produces metabolic changes in the severed nerve that include a biochemical, cellular adjustment to maintain neuronal integrity (Ducker et al, 1969). The nerve enters an anabolic, hypertrophic phase that rebuilds a functioning peripheral stump. Metabolically the ideal time for nerve repair occurs at 10 to 20 days. Use of a cylindric cuff may help to force a longitudinal alignment of neural and supporting elements. Recently a suggestion has been made that a cuff consisting of a segmental vein graft may be ideal for bridging a neural defect (Janecka et al, 1983). Undue delay in management leads to irreversible, degenerative changes in the anterior horn cells and to negative changes at the nerve-muscle interface that retard muscle reinnervation. The motor fiber arrangement within the facial nerve is such that the fibers to each of the terminal branches are scattered throughout the nerve (Gacek and Radpour, 1982). Recovery of facial nerve function after transection and repair requires 6 to 12 months. Fibrosis at the anastomosis reduces the number of nerve fibers that reach the periphery to 30% to 40% of the number potentially available (Fisch, 1974).

Evaluation of injury

Facial nerve injuries have been classified according to the following terminology:

1. *Transection* - clean, torn, with or without a missing segment.

2. *Pulsion* - a pulling or tearing of the nerve, as in a severe birth injury.

3. *Compression.*

4. *Crushing.*

Compression injury to the facial nerve may produce a functional deficit without anatomic disruption of the nerve itself. In these instances, the nerve is usually electrically responsive for 24 to 48 hours and then becomes unresponsive. Electrical stimulation produces a response once more after 5 to 14 days, and conservative treatment is recommended (Ge et al, undated).

The decision to repair a transected facial nerve branch is based in part on the anatomic location. Mustarde (1979) recommends surgical exploration and repair when the nerve transection occurs at a point lateral to a vertical line dropped from the pupil of the eye. Transection of the nerve medial to the pupillary line does not require surgical repair.

Uncomplicated nerve transection and repair

Despite some diversity of opinion, there tends to be agreement on the following points:

1. Use of the operating microscope facilitates surgical repair of the facial nerve trunk or branches.

2. The best results are obtained when the anastomosis is accomplished with fresh, sharp nerve ends.

3. Minimal trauma should occur to the nerve in its handling.

4. A minimal number of sutures should be used.

5. Tension or crowding on the anastomosis should be avoided (Fig. 60-7).

Some disagreement has arisen regarding the length of a defect that simple reanastomosis can manage. Parisier (1982) feels that 1 to 2 mm is the maximal gap that should be closed without using a graft; others recommend anastomosis in the case of defects ranging from 5 mm to 2.5 cm, using various techniques for rerouting the course of the nerve (McCabe, 1970).

Other areas of nonagreement include the following:

1. Immediate neural repair versus planned delay. McCabe (1970) recommends that the nerve be repaired initially only if it is cut at the time of parotid surgery, if both ends are fresh, or if the psychologic aspects of a transient facial nerve palsy are important. Otherwise, he suggests delay for 2 to 3 weeks.

2. The type of suture material. Recommendation include 6-0 silk (Conley, 1961; Grabb and Smith, 1979), 7-0 silk (Georgiade, 1969), 8-0 silk (Parisier, 1982), 8-0 monofilament suture (Lathrop, 1983; McCabe, 1970) and 10-0 monofilament suture (Fisch, 1974; Miehlke, 1974; Naumann, 1980).

3. Use and type of a splinting tube across the anastomosis. Those favoring the use of a tube recommend a polyethylene tube (Miehlke, 1974), a collagen tube (Fisch, 1974; Naumann, 1980), and a "plastic tube sometimes" (Conley, 1961). Lathrop (1983) recommends

no splinting tube, and McCabe (1970) suggests wrapping the anastomosis with "thin plastic sheeting" (Fig. 60-8).

4. Suture placement. Suggestions for suture placement vary, with Lathrop, Conley, Naumann, Miehlke and Georgiade recommending epineural sutures. Fisch, Millesi et al (1972), and Grabb and Smith (1979) recommend perineural sutures (Fig. 60-9).

5. Glue, resectin, and fascicular repair. Use o a synthetic or biologic glue at the anastomosis is recommended by Naumann (1980) (histacryl or plasma) and Fisch (1974) (butyl-2-cyano-acrilate). Resection of the epineurium is recommended by Fisch (1974), Grabb and Smith (1979), and Millesi et al (1972), and fascicular repair is emphasized by Millesi et al (1972).

Indirect anastomosis of the facial nerve

In the case of injury and tissue loss involving the marginal mandibular branch of the facial nerve, a significant lower lip deformity results from the loss of lip innervation. The cervical branch of the facial nerve is considered nonessential for facial expression and can be rerouted to perform an anastomosis with the distal segment of the marginal mandibular nerve. This branch can be identified using the electrical stimulator. Fig. 60-10 illustrates this technique. The repair is accomplished as with a transected nerve branch.

Nerve graft procedures

The following situations indicate the use of a facial nerve graft:

1. As an immediate reconstructive step when the nerve must be resected in the course of excision of a facial malignancy (Conley, 1961).

2. When the defect is greater than 2 mm (Parisier, 1982) or 2.5 cm if the surgeon is unable to reroute the nerve (McCabe, 1970).

The preferred donor sites for obtaining a nerve graft are the sural nerve, the greater auricular nerve, the lateral cutaneous nerve of the thigh, and the cervical plexus (Youngs and Walsh-Waring, 1987).

Further controversy exists over the appropriate timing for accomplishing a nerve graft.

1. Immediately (Conley, 1961).

2. 5 to 7 days (Lathrop, 1983).

3. At 3 days if able to stimulate percutaneously and at 20 days if not able to stimulate percutaneously (McCabe, 1970).

4. Within the first 3 weeks (Miehlke, 1974).

The surgical principles emphasized in nerve graft techniques are the following:

1. Excising and freshening of the ends of the facial nerve stumps.

2. Preparing a nerve graft that is 3 to 5 mm longer than the defect (Fig. 60-11).

3. Performing the nerve anastomosis immediately after harvesting the graft because any delay is extremely harmful.

4. Equalizing the size of the ends of the nerve stump and the graft at each anastomosis.

High-Pressure Hydraylic Injection Injury

Recent reports have emphasized the severity of an unusual type of soft-tissue injury that may involve the facial region. Various types of hydraulic injection equipment have been responsible for injuries that introduce petroleum products through the skin at pressures greater than 2000 lb/square inch (Smith et al, 1982). These injuries appear minor at first, with only a pinpoint site of entry. Subsequently, however, the patient develops localized necrosis and gangrene.

The pathophysioloy involves three wound stages. During the early and acute phase, progressive tissue necrosis occurs secondary to the mechanical pressure, chemical irritation, and subsequent development of infection. During the chronic phase, the tissue shows chronic inlammation, an intense foreign body reaction, and unusual oil-containing tumors (oleomas). The late sequelae of this injury involve the formation of many microabscesses.

Management of these injuries requires excision of all tissue that has been impregnated with oil, followed by copious saline irrigation and adequate wound drainage. The patients are placed on broad-spectrum antibiotics for 4 to 6 weeks.