CADAVERIC STUDY OF BLOOD SUPPLY TO THE LOWER INTRAORBITAL FAT: ETIOLOGIC RELEVANCE TO THE COMPLICATION OF ANAEROBIC CELLULITIS IN ORBITAL FLOOR FRACTURE

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Background and Purpose: Although orbital fractures are common, orbital cellulitis rarely develops following orbital fracture. We hypothesized that compromise of the blood supply to the intraorbital fat during orbital floor fracture is responsible for this condition. The purpose of this study was to determine whether or not the lower intraorbital fat is supplied by a branch of the infraorbital artery along the orbital groove or canal on the orbital floor.

Materials and Methods: sol we dissected 14 orbits from seven fixed human cadavers and 12 orbits from six fresh cadaver heads following dye injection into the maxillary artery. The sites of dye-filled vessels branching from the infraorbital artery supplying the lower intraorbital fat were measured and plotted on a two-dimensional orbital floor graph.

Results: A main branch of the infraorbital artery rose through the medial orbital floor to supply the lower intraorbital fat in all of the cadaver orbits. The sites of the branching point of the vessel ranged from 0 to 5 mm (mean, 2.2 mm; n = 14) medial to the line connecting the infraorbital foramen and the infraorbital groove. The shortest distance measured from the branching point to the orbital rim ranged from 3 to 20 mm (mean, 14.1 mm; n = 14). This suggests that if orbital fracture were to occur around the infraorbital groove or canal, this vascular pedicle would be in danger of being incarcerated by bone fragments.

Conclusion: Our cadaveric investigation revealed that the lower intraorbital fat is supplied by a branch of the infraorbital artery along the infraorbital groove or canal on the orbital floor. This finding suggests that compromised blood supply to the intraorbital fat may cause anaerobic cellulitis or enophthalmos.

The inferior orbital floor is vulnerable to increased pressure when blunt injury of the orbit occurs. The combination of the thinness of the maxillary roof, the presence of the inferior orbital fissure, and the curvature of the floor predisposes it to fracture [1]. Most orbital blowout fractures need early surgical exploration if computerized tomographic (CT) scan reveals herniation of orbital content into the sinus. Diplopia during upward gaze is usually a sign of entrapment of the extraocular muscles. Early repair of this condition with autogenous bone or alloplastic material is needed to prevent orbital content herniation.

Orbital cellulitis is frequently associated with sinus infection because of the close anatomic proximity of the sinus and the orbit. We previously treated a male patient suffering from orbital anaerobic cellulitis. He had no history of chronic paranasal sinusitis and this condition was diagnosed 3 days after a traffic accident. CT examination revealed extensive subcutaneous emphysema. Gangrenous intraorbital fat and blowout...
fractures of the floor and medial wall of the orbit were found during surgery. The anaerobic infection, proven later by culture, was facilitated within the anaerobic condition of the gangrenous lower intraorbital fat. The vascular pedicle of this fat pad was very likely pinched by fracture fragments. The purpose of this study was to delineate the patterns of blood supply to the intraorbital fat by examination of dye injection and cadaver dissection. The anatomy of the blood supply to the lower intraorbital fat has not previously been reported.

**Materials and Methods**

**Case report**

A 22-year-old man was admitted to the emergency ward with erythema and swelling in the right lower eyelid and preorbital region accompanied by pain and foul-smelling discharge (Fig. 1). Three days earlier he had a motorcycle accident, which caused a blunt injury to the right eye. Physical examination revealed a fever of 39.4°C. Visual acuity was poor in the right eye (OD, 20/200; OS, 20/20). Intraocular pressures on the right side were mildly elevated (OD, 25.1 mm Hg; OS, 14 mm Hg). Proptosis and limitation of eyeball movement in all directions were found in the right eye. The pupils and the fundus were normal, confrontation fields were intact, and the white blood cell count was 15,200/µL. CT scan showed a right orbital floor and medial wall blowout fracture with a substantial increase in air in the orbital cavity and subcutaneous tissues of the lower eyelid (Fig. 2) compared to those observed on CT scan on the first day after trauma (Fig. 3). Fluid in the maxillary and ethmoid sinuses was also observed on CT scan. After admission, the patient was given intravenous oxacillin 1 g every 6 hours and gentamycin 80 mg every 8 hours. Emergency wound drainage of about 50 mL of pus and surgical drainage of the right maxillary sinus were performed via a Caldwell-Luc incision 2 days after admission. The central pad of the lower intraorbital fat was found to be gangrenous (Fig. 4) and was excised. Cultures of the gangrenous tissue were positive for *Peptostreptococcus* spp and *Viridans streptococci*, which are anaerobic and facultatively anaerobic, respectively. Since these two cocci were sensitive to most drugs tested, including penicillin, ampicillin, clindamycin, and metronidazole, we replaced gentamycin with metronidazole 450 mg every 6 hours for 1 week. Treatment with parenteral postoperative antibiotics lasted for 2 weeks and was then changed to oral amoxicillin 500 mg
plus clavulanic acid 250 mg every 8 hours. Three weeks after drainage and debridement, an autogenous bone graft was harvested from the iliac crest to repair defects of the orbital floor and medial wall. Reattachment of the medial canthal ligament and dacryocystorhinostomy corrected the telecanthus and the injured lacrimal sac, respectively. The patient had recovered satisfactorily at 6 years’ follow up. There was no diplopia, enophthalmos, or limitation of eyeball movement.

**Cadaveric studies**

Fourteen orbits from seven fixed Chinese cadavers (5 male and 2 female, donated by families for gross anatomic dissection in the Department of Anatomy, National Taiwan University College of Medicine) and six fresh Caucasian cadaver heads (all male, Lifelegacy Foundation, AZ, USA) were dissected after injection of 3 mL methylene blue via a 23-gauge intravenous catheter inserted within the maxillary artery at the region of the pterygopalatine fossa. The periorbita was elevated gently after blunt dissection through a subcilliary skin incision. A consistent branch of the infraorbital artery, arising from the medial side of the orbital floor, was found to supply the orbital fat in all orbits. The distance of the branching point of the vessel perpendicular to the line connecting the infraorbital foramen and the infraorbital groove was measured (Fig. 5). The shortest distance from the branching point of the vessel to the orbital rim was also measured. The points were plotted on a two-dimensional graph of the orbital floor.

**Results**

Dissection after dye injection confirmed that the blood supply to the lower intraorbital fat consistently rose through the orbital floor along the infraorbital canal or groove. The infraorbital artery was observed to enter the orbit through the inferior orbital fissure and to run forward in the infraorbital groove and canal, and then to emerge on the face from the infraorbital foramen in all cadavers. In the orbit, the infraorbital artery was also observed to supply branches to the inferior oblique and inferior rectus muscles. The facial branches of the infraorbital artery supply the lower eyelid, and anastomose with the branches of the facial artery and with the terminal branch of the ophthalmic artery and the dorsal nasal artery in all cadavers. The lengths of the infraorbital grooves varied, with only one orbit having no groove, that is, the infraorbital vessels and nerves were within the canal.

In all fixed orbits, one major branch from the infraorbital arteries was found rising through the orbital floor (Fig. 6). In two orbits, another smaller branch from the infraorbital artery was found accompanying a branch of the infraorbital nerve; this nerve branch also innervated the orbital fat. The sites of the branching points ranged from 0 to 5 mm (mean, 2.2 mm) medial to the line connecting the infraorbital foramen and the infraorbital groove. The shortest distance measured from the branching point of the vessel to the rim ranged from 3 to 20 mm (mean, 14.1 mm) (Fig. 5).
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The findings in the fresh cadaver heads were similar to those in orbits from fixed cadavers except that there were more cadavers with one or two additional smaller branches of the infraorbital arteries supplying the lower intraorbital fat (in 5 orbits) (Fig. 7). These additional branches accompanied the nerve branches from the infraorbital nerve. A bilateral arterial connection was present in four of the fresh heads; the dye frequently appeared in branches of facial arteries on the contralateral side through the facial branch of the infraorbital arteries, angular arteries, and dorsal nasal arteries. However, the lower intraorbital fat received blood supply only from the branches of the infraorbital artery in all orbits, as demonstrated by dye-filled branches of ophthalmic arteries and facial arteries after dye injection via ophthalmic arteries and facial arteries, respectively, in two fresh cadavers.

Discussion

Most cases of orbital cellulitis occur after sinus infection because of the close anatomic relationship between the sinuses and the orbits. In pediatric patients, almost all reported cases of orbital cellulitis are secondary to sinusitis [2]. A break in the floor or medial wall of the orbit may facilitate direct extension of a sinus infection. However, acute sinusitis might occur after trauma since bleeding into the sinus or orifice occlusion of the sinus will encourage bacterial growth in such a closed environment. It is also possible that an environment that facilitates bacterial growth may be created due to the presence of ischemic or necrotic fat tissue. Since the branch of the infraorbital artery that supplies the orbital fat runs along the infraorbital groove or canal, the thinnest part of the orbital floor, this vascular pedicle may easily become incarcerated during fracture, just as the infraorbital nerve may become injured with the resulting symptom of numbness on the cheek.

Zimmerman and Bilaniuk reported the largest series of orbital cellulitis with 18 cases [3]. In their series, the most common cause of orbital cellulitis was sinusitis (8 cases), followed by trauma (orbital fractures or foreign bodies; 7 cases). Orbital cellulitis might also occur after repair of the orbital floor defect with an alloplastic implant [4]. In a retrospective study of 130 orbital infections by Silver et al, three cases of severe orbital infection were identified as being associated with an orbital fracture [5]. The risk is higher in those who have a contaminated sinus [6] or foreign bodies within the orbit [7]. There is a paucity of literature reporting the results of culture for anaerobic orbital cellulitis. The causes of anaerobic orbital cellulitis in reported cases were usually chronic paranasal sinusitis in pediatric patients [8, 9] or foreign bodies such as pieces of wood [7]. Anaerobes are normal flora in the oronasal cavity. In traumatized ischemic tissues, such as in our patient, anaerobic infection should be considered as one of the diagnoses. Many factors of orbital blowout fracture tend to encourage anaerobic growth, such as increased pressure and, thus, compromised circulation due to swelling, hematoma, or obstruction of the sinus opening by blood clot, or the presence of necrotic tissue, as demonstrated in the present case. This situation is similar to the chronic paranasal sinus-
tis in which anaerobes play an important role [10]. Heightened awareness of the role of anaerobes in sinusitis and of the possibility of anaerobic orbital cellulitis following trauma may lead to the identification of more cases.

Orbital defects should be reconstructed early before scarring or enophthalmos becomes evident. Grafts used in orbital reconstruction are divided into two major categories: autogenous tissues and alloplastic material. Autogenous bone grafts provide the advantage of reduced risk of infection compared to alloplastic material [1, 11]. In our patient, the use of an autogenous iliac bone graft was delayed for 3 weeks until the sinus was drained and the wound was clean. Our patient did not experience enophthalmos and the bone graft had taken well after 6 years' observation. This case suggests that autogenous bone graft is suitable for dealing with orbital floor defect early after cellulitis resolves. However, precautions against nose blowing and straining should be instituted regardless of whether surgical repair is to be performed.

CT scan is very informative for evaluating orbital fracture and orbital infection [12]. It is capable of defining the extent of inflammation and showing the anatomic association among the orbits, paranasal sinuses, and intracerebral structures. With 1-mm-section high-resolution CT, it is possible to observe the optic canal [13]. Goodwin et al found that, when orbital abscesses were present, CT scan was useful in evaluating the indications for drainage [14]. Orbital air accumulation is a frequent finding in orbital fracture due to adjacent sinuses or air cells, but rapidly increased air accumulation, such as demonstrated in the CT scan of our patient, is a sign of anaerobic infection, which might be misread as entrapped sinus air.

The application of antibiotic prophylaxis to fractures of the orbital floor is controversial. Normal sinuses are considered sterile [15]. This is not the case for the nasopharynx or oropharynx, nor is it true in cases of sinusitis. Therefore, it is appropriate to use prophylactic antibiotics when chronic sinusitis or communication into these spaces is suspected [16]. Antibiotics should be administered as a single preoperative dose, or in a trauma setting, within 3 hours of wounding. If surgery lasts longer than 4 hours, a second intraoperative dose may be given [16]. Unless a specific organism is suspected, a first-generation intravenous cephalosporin such as cefazolin diminishes the incidence of postoperative infections in facial fractures [17]. When a graft is used in orbital reconstruction, antibiotic prophylaxis is definitively necessary. The present case suggests the importance of anaerobes and their coverage with antibiotics in dealing with facial fractures.

In surgery of the orbit, adequate exposure along the orbital floor requires careful recognition and often division of the orbital branches of the infraorbital artery. Failure to recognize the orbital vascular pedicle may lead to the severe complications of postoperative retrobulbar hemorrhage or even visual loss [18]. Posttraumatic retrobulbar hemorrhage is probably related to the tearing of the infraorbital vessels or their branches. Many cases of retrobulbar hemorrhage and blindness after cosmetic blepharoplasty undoubtedly might occur from inadequately ligated stumps of prolapsed fat and its vascular pedicle [19]. In the present cadaver study, we found that the branching point of this pedicle was around 1.4 cm deep to the orbital rim and several mm medial to the infraorbital canal. Awareness of the characteristics of this structure is important to surgeons who must control the bleeding in cases of suture slippage or postoperative rebleeding.

Enophthalmos secondary to a blowout fracture is thought to be due to significant herniation of orbital contents into the maxillary sinus or an enlargement of the orbital volume. In addition, late enophthalmos may be secondary to atrophy or necrosis of orbital fat [20]. The thinnest portion of the orbital floor surrounds the infraorbital groove. Involvement of the infraorbital vessel and nerve and resultant atrophy of orbital fat and infraorbital anesthesia are common during orbital fracture. This late enophthalmos, frequently encountered even after floor reconstruction, supports our hypothesis that the blood supply to the infraorbital fat is from the infraorbital artery, which is vulnerable to injury during orbital blowout fractures. The ophthalmic artery, the major branch of the internal carotid artery in the orbit, supplies the retina and most of the extraocular muscles, and is connected with branches of the external carotid artery including the infraorbital artery through the dorsal nasal artery. However, the lower infraorbital fat does not receive blood supply directly from the ophthalmic artery [20].

In conclusion, by the intra-arterial injection of methylene blue and subsequent dissection of 26 orbits in cadavers, we found that there was at least one branch from the infraorbital artery supplying the lower infraorbital fat in each orbit. This finding suggests that in orbital floor fractures, these vessels are likely to become incarcerated. The orbital fat with compromised blood flow is prone to anaerobic infection by contamination from an adjacent sinus. Broad-spectrum antibiotics including coverage of anaerobes are recommended in managing patients with orbital blowout fractures due to the likelihood of anaerobic infection.

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References