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A HISTORICAL PERSPECTIVE OF LATERAL CANTHOTOMY AND ITS ADOPTION AS AN EMERGENCY MEDICINE PROCEDURE

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□ **Abstract—Background: The treatment of orbital compartment syndrome has a rich history rooted in surgery and emergency medicine. It is a rare but acute and vision-threatening condition that most commonly occurs secondary to facial trauma or as a postoperative complication, and was first recognized in 1950. Surgical techniques and medical management were developed and refined soon afterwards to eventually become the modern-day treatment, lateral canthotomy, and inferior cantholysis. Objective: This article details the history of orbital compartment syndrome and the evolution of its treatment to the present day. Discussion: Given the time-sensitive nature and acuity of orbital compartment syndrome, lateral canthotomy was adopted by emergency physicians who could perform it more quickly at the bedside. Conclusions: Lateral canthotomy is a procedure adopted by emergency physicians from the surgical literature. The history of its adoption is a representative example of how emergency medicine evolves as a field.** © **2018 Elsevier Inc. All rights reserved.**

□ **Keywords—lateral canthotomy; inferior cantholysis; history; history of medicine**

INTRODUCTION

Lateral canthotomy with inferior cantholysis is a rare emergency procedure indicated for acute orbital compartment syndrome (OCS), a vision-threatening increase in intraorbital pressure. Retrobulbar hematoma secondary to trauma or surgical complication is the most common cause of OCS, although etiologies, such as malignancy with mass effect or inflammation, can also cause increased compartment pressures (1–3). Lateral canthotomy to decompress OCS is generally performed by emergency physicians or ophthalmologists and involves making a lateral 1- to 2-cm incision from the lateral canthus. The inferior cantholysis is performed by reflecting the lower lid and incising the inferior canthal tendon, which relieves intraorbital pressure (4,5). Failure to decompress OCS within 90 min can result in permanent blindness (6).

DISCUSSION

Discovery of OCS

The first case report of monocular blindness caused by acute OCS was published in 1950 in the plastic surgery literature by Gordon and McCrae as a complication of traumatic zygomatic bone fracture repair (7). The patient developed monocular blindness on the side of the surgery, but the authors were ultimately advised not to operate to decompress the orbit by a neurosurgical colleague (7). In their paper, they proposed that the monocular blindness was caused by intraorbital hemorrhage compressing the optic nerve and causing vision loss.

The first animal model of OCS secondary to retrobulbar hemorrhage was created in 1969 by Hunter in cynomolgus monkeys by obtaining samples of autogenous blood and injecting it into the orbit to induce proptosis. The subsequent blindness of the monkeys was proposed

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to be due to the increased intraorbital pressure causing collapse of the veins draining the optic nerve (8). Huang et al. (9) also created a rabbit model of OCS in 1977 by injecting autogenous blood or normosaline into the orbit, with findings similar to those in prior published cases of OCS.

History of the Lateral Canthotomy

The early literature of the treatment of acute OCS revolves around a collection of case reports. Early procedures for decompressing the orbit were generally more invasive and technically challenging than the modern lateral canthotomy.

The earliest procedure for orbital decompression was performed in 1953 by Penn and Epstein, who published a case report of a patient with zygomatic bone fracture who re-presented 7 days after reduction of the fracture with proptosis and a fully dilated pupil (10). They used two incisions above and below the external canthus and inserted rubber drains, reporting that the proptosis resolved and the pupil constricted to normal size soon after. Gordon, who with McCrae published the first case of OCS in 1950, later published a similar case with a more effective intervention in 1957 for a patient with zygomatic bone fracture (7,11). Gordon made a 0.75-inch transverse incision laterally from the junction of eyelid and cheek skin under the mid-third of the palpebral fissure and bluntly dissected through this incision, immediately relieving the orbital pressure (7). He placed a drainage tube in the orbit, which was removed 24 h later without complication. The patient was seen several months later with normal visual acuity in his right eye.

Approaches to decompress the orbit were further refined during this period. In 1957, Walsh and Ogura described a case series in which they decompressed the orbit via a transantral approach through the orbital floor (12). The first open surgery to decompress the orbit was detailed by Barclay in 1963, in which, during a traumatic zygomatic fracture repair, a hematoma in the left orbit was evacuated with a frontal approach, in which the orbit was approached through the bone superiorly (13). In 1967, Fry presented a case report of a patient presenting 2 days after zygomatic bone repair with proptosis and conjunctival edema (13). Fry decompressed the orbit with a curved 2-cm incision inferior to the lateral eyebrow. He then dissected the orbicularis oculi down to the periosteum, which he opened and through which he placed a Penrose drain. Clinical improvement was seen within 30 min and Fry described the procedure as taking fewer than 10 min to complete by any general, plastic, or ophthalmology surgeon (14).

The first lateral canthotomy to treat OCS was performed in 1973 by Jafek et al. for a cosmetic blepharoplasty complication (15). Two canthotomy incisions were made from the lateral canthus and an incision was made through the inferior orbital septum to evacuate the hematoma. The next documented lateral canthotomy was reported in the literature in 1977 by Clever and Herzen to decompress the orbit of a 5-year-old boy with unilateral proptosis and a firm globe following blunt trauma to the eye (16). The lateral canthotomy was performed under local anesthesia with resolution of proptosis. In 1981, Gillum and Anderson describe the first case report of emergency orbital decompression with lateral canthotomy being performed to reverse complete vision loss (17).

A case series by Ord in 1981 used the lateral brow approach as described by Fry in 1967, as well as a Caldwell-Luc approach through the anterior maxilla to decompress the orbit through the orbital floor after a postoperative zygomatic bone repair complication (14,18). The infraorbital incision was reopened and a sinus forceps was used to open the orbital floor, from which the hematoma was evacuated. A drain was placed and the patient had no visual impairment to that eye 1 week after the operation, marking the first case in the literature of an orbital hematoma evacuation through the orbital floor. In cases of OCS refractory to lateral canthotomy and inferior cantholysis, aggressive approaches through the ethmoid sinus or sphenoid sinus may be used to decompress the orbit (19).

Medical Management of OCS

The earliest proposed medical management of OCS was written by Ord in 1981 (18). Ord proposed attempting medical management before surgical intervention with 200 mL 20% mannitol i.v. and 500 mg acetazolamide i.v. to reduce the volume of the intraocular fluid and relieve intraocular pressure. Wood published a case in 1989 where he added 200 mg hydrocortisone to Ord's proposed treatment (18,20). In Wood's case report of an orbital blow out fracture, the surgical decompression procedure was postponed due to marked improvement of pain and vision within 10 min. Other case series in this time also used similar medical management of OCS (21).

Modern Lateral Canthotomy

The lateral canthotomy as it is currently done was first introduced in the literature by Thompson et al. in 1990 in a series of two cases of orbital hemorrhage during ethmoid surgery (22). The lateral canthotomy is proposed as a step in a sequential treatment algorithm for orbital hemorrhage in which medial orbitomy is to be attempted first, followed by lateral canthotomy with inferior cantholysis, then by inferior orbital decompression. They

describe the technique for the lateral canthotomy as it is currently done—first, a hemostat is placed into the palpebral fissure and clamped to devascularize the area around the canthus. After 1 min of occlusion, scissors are used to make a lateral incision from the lateral canthus of all layers from skin to conjunctiva. Thompson et al. proposed that these surgical interventions should occur simultaneously with medical management of mannitol, acetazolamide, and dexamethasone, similar to what was proposed by Wood (20). Bailey et al. also detailed lateral canthotomy in 1993, using techniques similar to those outlined by Thompson et al, but they do not follow the algorithmic procedure described by Thompson et al., suggesting that lateral canthotomy be performed immediately (19,22). In 1994, Yung et al. were the first to take intraocular pressure measurements comparing lateral canthotomy alone, inferior cantholysis, and canthal tendon dissection (23). They found that in a cadaveric model, canthotomy with cantholysis resulted in a significantly greater reduction in intraocular pressure than canthotomy alone or central tendon disinsertion.

Case reports of lateral canthotomy continued to be published through 1995, when Sampath et al. published a case report of a man with a traumatic eye injury whose OCS was relieved with a lateral canthotomy, demonstrating that the optic nerve can regain function with rapid lateral canthotomy (24). Goodall et al. published a case series of 5 patients in 1995, 2 of whom had lateral canthotomy with inferior cantholysis to treat OCS from traumatic etiology (25). The first review of orbital decompression was published by Soare et al. in 2015, which reviewed 89 cases of acute OCS published between 1994 and 2014, concluding that lateral canthotomy was the most commonly used and effective method for treating OCS and that surgical intervention should not be delayed for medical management or imaging (26).

Lateral Canthotomy Emerges as an Emergency Medicine Procedure

In the 1990s, lateral canthotomy began to be more commonly described in the emergency medicine literature as a procedure that could be performed by emergency physicians. Hislop et al., oral and maxillofacial surgeons, performed the first bedside lateral canthotomy in the emergency department under local anesthesia (27). The first case published in the emergency medicine literature was by Knoop and Trott in 1994, in a review that lists ophthalmologic procedures that can be performed by emergency physicians (28). Two years later, Hislop et al. published the results of a questionnaire they sent to emergency physicians regarding retrobulbar hemorrhage in the emergency department (27). In this survey, they deemed 83% of the senior house staff and 37% of the senior physicians unable to diagnose and treat retrobulbar hemorrhage, prompting Hislop to write an emergency department protocol for diagnosis and treatment of retrobulbar hemorrhage. By the late 1990s, still only a few cases of lateral compartment syndrome had been reported in the emergency medicine literature (28–30). A porcine model was developed by emergency physicians Suner et al. in 2000, recognizing that lateral canthotomy and inferior cantholysis is a rare but critical procedure for emergency physicians (31). In this model, 15–20 mL saline was injected behind the orbit to mimic OCS. Twenty-two house staff were trained using this model and video of the demonstration was made publicly available online.

In 2002, Vassallo et al. published the first comprehensive case report in the emergency medicine literature of OCS treated with lateral canthotomy with inferior cantholysis (4). This case published by Vassallo et al. affirmed the importance of emergency physicians being able to perform a lateral canthotomy and is still widely cited. Throughout the 2000s, emergency physicians continued to publish case reports of OCS treated with bedside lateral canthotomy (32,33). In the emergency medicine cases that were published, trauma is a more common etiology of OCS, rather than postoperative complication more commonly seen in the surgical literature.

Rodriguez et al. discuss lateral canthotomy for the first time in the family medicine literature in 2003, in a review article discussing eye injuries related to sports (34). A year later, Benton, a family medicine physician working in an emergency department, published a case in which he performed a lateral canthotomy (35). In this case report, Benton states that diagnosing and treating OCS is necessary for sports medicine physicians, especially where ophthalmology is not immediately available. In 2014, Sun et al., ophthalmologists, published a case series of eight lateral canthotomies that were performed in emergency departments, concluding that prompt surgical management is extremely important and that emergency physicians should be familiar with the procedure (36). This claim was later supported in the ophthalmology literature in 2015, when Pamukcu and Odabaşı published a review of OCS stating that it is preferable that an ophthalmologist performs the lateral canthotomy, but emergency physicians should be trained to do so in situations where ophthalmology is unable to treat the patient promptly (37).

Modern Practice of Lateral Canthotomy in the Emergency Department

In the present day, lateral canthotomy is taught as part of the emergency medicine residency curriculum. Although it is a rare procedure for emergency

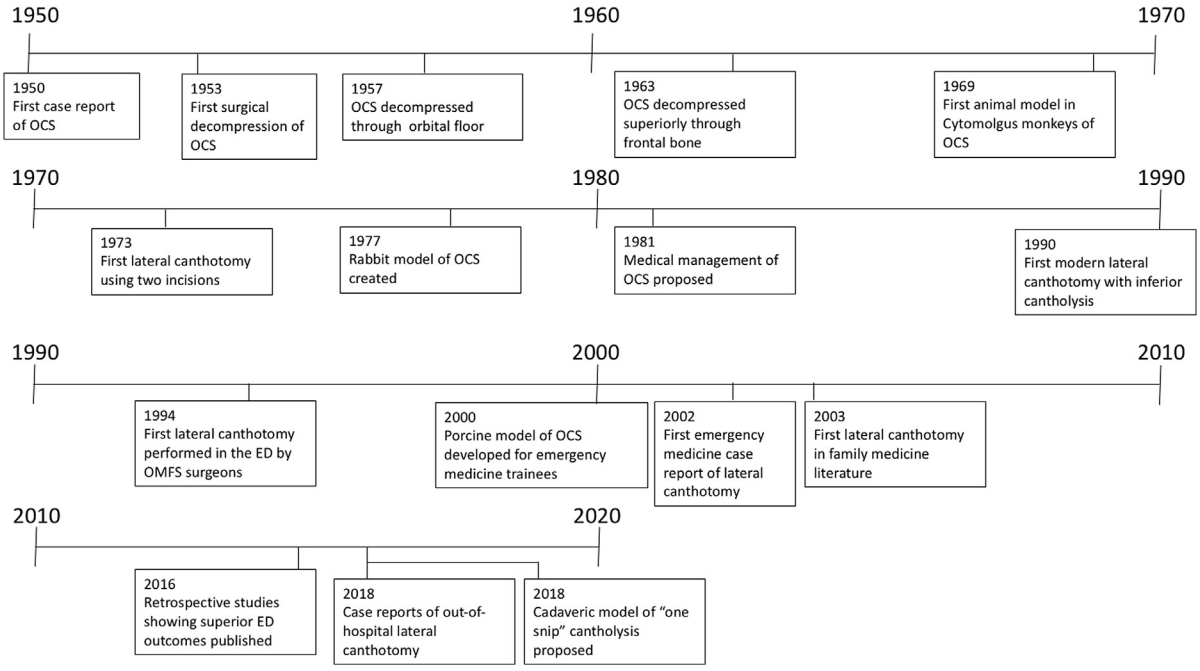

Figure 1. Timeline of the treatment of orbital compartment syndrome and development of lateral canthotomy. OCS = orbital compartment syndrome; ED = emergency department; OMFS = oral and maxillofacial surgery.

physicians, it remains a well-discussed topic in emergency medicine education (38).

A larger retrospective clinical study of lateral canthotomy specifically done by emergency physicians was published as an abstract by Beams et al. in 2016 (39). This study was a review of patients with retrobulbar hemorrhage who underwent lateral canthotomy and included 77 patients during a 15-year period. In the study, 52% of patients were discharged with baseline vision, with significantly higher baseline vision in the "early canthotomy" (<3 h from symptom onset to canthotomy) vs. "late canthotomy" group. In this study, canthotomy after symptom onset was performed in the emergency department significantly sooner than in the operating room (162 vs. 414 minutes; $p < 0.001$) and canthotomy performed by emergency physicians was performed significantly sooner than by specialists (155 vs. 302 minutes; $p < 0.001$). Early canthotomy had significantly better outcomes for baseline vision, decreased vision, and visual loss compared to late canthotomy ($p < 0.01$ for all comparisons). Given the time-sensitive nature of the outcomes, Beams et al. make a strong case for the necessity of emergency physicians to be able to treat and recognize OCS. Unfortunately, the study does not include complication rates of emergency physicians vs. subspecialists in performing the lateral canthotomy.

Recognition and treatment of OCS is now part of the emergency medicine residency curriculum. Many systems with animal, cadaveric, and simulation models of lateral canthotomy are currently used to train emergency medicine residents (31,40,41). Modern augmented reality technology has also been proposed for this training to better simulate the visual aspects of the orbit (42).

Recent Findings and Future Direction

The use of clinical ultrasound has increased in recent years, especially within the emergency department, functioning as a rapid and cheap bedside imaging modality. The ultrasound findings of OCS in one case study have been described as the "guitar pick sign," as the hyperechoic conical deformation behind the globe appears as a shape similar to a guitar pick. The guitar pick sign was no longer present after lateral canthotomy and inferior cantholysis, suggesting that it is caused by orbital hemorrhage compressing the globe (43). Another case describes a thin hypoechoic stripe behind the orbit in a case of early retrobulbar hemorrhage (44). Given that there are only very few cases of correlation of ultrasound findings, more research needs to be conducted to clinically correlate bedside imaging.

Out-of-hospital treatment of OCS has also been discussed (45). In a case by Hill et al., emergency physicians on an ambulance service in Australia treated a 21-year-old female shot in the head with signs of OCS (46). A short case series of prehospital lateral canthotomy was published in 2018 by Whitford et al., in which 2 of 3 patients in the case series successfully had OCS treated with lateral canthotomy in the field (47). These prehospital

canthotomies were all performed by emergency physicians riding on transport units; the articles do not comment on whether non-physicians should be able to perform lateral canthotomies in their scope of practice. Ballard et al. propose that medical sergeants should be trained and able to perform lateral canthotomy because they will likely be treating trauma patients in settings far away from higher levels of medical care (5). Lateral canthotomy has recently been discussed in the wilderness medicine literature, where Iserson et al. propose using alternate tools, such as a Swiss Army multi-tool (40).

In 2018, Blandford published a modified "one-snip" procedure for decompressing retrobulbar hemorrhage. The one-snip procedure involves making a single 15 mm full-thickness eyelid cut 5 mm medial from the lateral canthal angle 45° inferolaterally, creating an inferolateral cantholysis and septolysis. They found that this method had no significant differences in reducing intraorbital pressure compared to lateral canthotomy and inferior cantholysis, and that it could be trialed as an alternative procedure (48).

CONCLUSIONS

The treatment of OCS has a fascinating history originating in the surgical literature, from its discovery in 1950 to present day. Its treatment evolved from invasive open surgery to a simple bedside procedure with aspects of medical management. The adoption of lateral canthotomy and inferior cantholysis by emergency physicians has saved the vision of many patients due to the time-effectiveness of performing the procedure quickly in the emergency department. Given that increased time from symptom onset to treatment has been demonstrated to be associated with poor outcomes, new discussion about out-of-hospital lateral canthotomy and inferior cantholysis and novel procedural techniques for decompressing orbital pressure are being developed, which are promising measures for improving OCS outcomes (Figure 1).

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ARTICLE SUMMARY

1. Why is this topic important?

This review offers a historical perspective of how lateral canthotomy, originally a procedure performed only by surgeons, became adopted by emergency physicians. It is a representative and historically intriguing example of how practice changes occur in emergency medicine.

2. What does this review attempt to show?

This review is a historical perspective piece, rather than a traditional scientific literature review, which shows the history of the adoption of lateral canthotomy as an emergency medicine procedure.

3. What are the key findings?

This review includes the history of medicine of the lateral canthotomy within the emergency medicine and surgical literature and discusses the future direction of lateral canthotomy as an emergency medicine procedure.

4. How is patient care impacted?

As a historical review piece, this is a unique perspective of the evolution of a treatment, including how its practice is changing in the current day. It offers emergency physicians an opportunity to consider lateral canthotomy and other treatments in how the practice of emergency medicine changes to adopt procedures and treatments from all fields of medicine.