Introduction

Capillary hemangiomas are common benign infantile tumors of the eyelid and orbit. Untreated capillary hemangiomas can lead to amblyopia from mechanically induced astigmatism or occlusion of the pupillary axis. The convenience, efficacy, and low systemic side effects of an intralesional corticosteroid injection have made this method the mainstay therapy for many of the vision-threatening capillary hemangiomas. However, a permanent loss of vision can result from a central retinal artery occlusion (CRAO) by a retrograde embolization of the injected drug, and this remains the principal concern for parents and physicians.

Background and Objective: To describe a corticosteroid injection technique for eyelid capillary hemangiomas that minimizes the risk of a central retinal artery occlusion and is based on anatomic, physiologic, and pharmacologic rationales.

Patients and Methods: In this retrospective, non-comparative, interventional case series, the medical records of 50 eyes of 50 patients over a 10-year period were reviewed for retinal complications associated with the described injection technique.

Results: Ophthalmoscopy showed no retinal complications in the 50 eyes treated with this injection technique.

Conclusion: The risk of central retinal artery occlusion from retrograde embolization can be minimized by using an anatomically based injection technique that prevents canalization of an artery and avoids injection pressures exceeding the mean systemic arterial pressure.


An Anatomically Based Approach to Intralesional Corticosteroid Injection for Eyelid Capillary Hemangiomas

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The putative mechanism for the CRAO associated with a periocular intralesional corticosteroid injection is thought to arise from particulates of the steroids entering a periorbital artery at the point of injection and passing in a retrograde direction to the point where the central retinal artery branches off the ophthalmic artery. Once the anterograde arterial pressure exceeds the retrograde injection pressure, forward arterial flow propels the steroid particulates into the narrower central retinal artery leading to vascular occlusion (Fig. 1).

Three concurrent factors contribute to retrograde embolization. The injection needle cannulates an arterial vessel within or surrounding the vascular tumor, the injection pressure exceeds the systemic mean arterial pressure, and the steroid aggregates in the blood. Based on anatomical and physiological rationales, we present an injection technique that attempts to modify the factors that may be contributory to retrograde steroid embolization following intralesional injection for periocular capillary hemangioma.

**PATIENTS AND METHODS**

The records of all patients with eyelid capillary hemangioma treated or supervised by one of the authors (DTT) using the following technique between January 1, 1999, and January 1, 2009, at the Bascom Palmer Eye Institute were reviewed. Clinical notes, correspondence with the referring physician, and operative reports were studied for evidence of injection-related retinal arterial complications.

**Injection Technique**

Patients showing evidence of amblyopia due to capillary hemangioma-induced astigmatism or visual deprivation and refractory to patching therapy were selected for intralesional steroid injection. Each patient received one drop of 1% cyclopentolate in both eyes approximately 20 minutes before surgery. Indirect ophthalmoscopy was performed prior to injection of corticosteroids to confirm that the fundus was normal. The corticosteroids used were a 50-50 mixture of triamcinolone acetonide (40 mg/mL Kenalog-40; Bristol-Meyers Squibb, Princeton, NJ) and a mixture of betamethasone sodium phosphate and betamethasone acetate (6 mg/mL Celestone Soluspan; Schering Co., Kenilworth, NJ). A 10-cc syringe was used to draw up 0.75 cc of triamcinolone acetonide and 0.75 cc of betamethasone sodium phosphate with enough space to mix the suspension. A 27-gauge needle was used for the injection. In consultation with the anesthesiologist, patients were encouraged to continue clear liquids up to 2 hours before surgery to prevent a decrease in mean arterial pressure associated with hypovolemia during deep anesthesia.

The positioning and direction of the injection needle was based on the location of the periocular capillary hemangioma and knowledge of the regional vascular architecture. The needle was directed perpendicular to the orientation of the arterial vessels in the vicinity of the tumor to minimize an inadvertent arterial cannulation (Fig. 2).
Alternatively, the needle can be positioned parallel to the regional arterial vessels and pointed in the direction of forward flow of these vessels (Figs. 2 and 3). For example, if the lesion is located predominantly along the pretarsal region and in proximity to the peripheral and marginal arterial arcades, the needle enters the mid-level and nasal side of the lesion, avoiding its base, and aims toward the temporal eyelid. If the lesion is located in the corrugator region, the needle enters the lesion from the dorsal margin and aims toward the eyelid margin, away from the supraorbital vascular bundle and in the forward direction flow of the arterial vessel. An option is to insert the needle into the lesion from the temporal side, perpendicular to the orientation of arterial vessels emanating from the supraorbital notch. Under no circumstances should the needle be directed toward the supraorbital notch.

With either of these approaches, the needle is inserted into one end of the tumor and passed through the core until reaching the distal edge. Before injection, an assistant applies digital compression on the supraorbital vascular bundle (Fig. 4). The drug is then slowly injected while withdrawing the needle from the core of the lesion. Depending on the size and shape of the tumor, the needle may be redirected within the lesion from the same puncture site to deliver the drug to other parts of the mass, but one should generally avoid injecting more than 1.5 cc of the corticosteroid suspension in a given session.

Indirect ophthalmoscopy was performed on both eyes immediately after the injection to look for signs of retinal vascular occlusion.

The outcome measure is reduction in tumor size with improvement in visual functions. In patients demonstrating shrinkage of the mass but with suboptimal improvement in hemangioma-induced astigmatism or visual deprivation, a second injection is given within 2 to 3 months. The surgical aim is not to achieve complete resolution of the tumor mass, but to diminish its mechanical effect contributing to amblyopia.

**RESULTS**

Fifty eyes received steroid injections for capillary hemangioma at the Bascom Palmer Eye Institute over this 10-year period. All demonstrated a reduction in tumor size following initial injection; four lesions required a second injection to achieve further reduction in mass effect for visual function improvement. No retinal vascular occlusions were noted at the time of each injection or reported by the referring pediatric ophthalmologists on follow-up examinations.

**DISCUSSION**

The exact mechanism leading to the central retinal artery occlusion following corticosteroid injection for capillary hemangioma has not been determined, but contributing factors may be related to the technique of injection and the pharmacological properties of the steroid suspension. We proposed an injection technique based on anatomical, physiological, and pharmacological rationales to further minimize this rare devastating complication. These principles can be used to prevent vascular complications during other periocular injections.

Inadvertent cannulation of the arterial vessel is a
potential risk and can be minimized by the needle selection and orientation during the injection. Needle size should be small enough to minimize damage to infant tissue but large enough to avoid arteriolar cannulation. The luminal diameter of adult periorcular arterioles averages 0.50 mm. The diameter of an infant eyelid arteriole is not known but is presumably much smaller than that of an adult. The outside diameter of a 27-gauge needle is 0.41 mm, and the likelihood of this needle cannulating the lumen of a smaller caliber vessel is low. The needle will most likely lacerate the vessel rather than cannulate it and is sufficiently small to minimize tissue damage.

In the event of inadvertent arterial cannulation, retrograde flow of the steroid solution can only occur when the injection pressure exceeds the arterial pressure. Infantile mean arterial pressure is approximately 70 to 50 mm Hg and increases with age. Egbert et al. used 3-cc syringes with a 21-gauge cannula to measure the injection pressures during intralesional corticosteroid injections for capillary hemangioma. In 63 of 71 injections, the maximum pressure exceeded 100 mm Hg. This occurred despite the attempt to inject with the least amount of pressure. Because the injection pressures will often exceed arterial pressures, efforts should be made to maximize the mean arterial pressure and minimize the injection pressure.

Injection pressure can be affected by the caliber of the needle and syringe. Pascal’s law states that $P = F/A$, where $P$ = pressure, $F$ = force, and $A$ = area. Given that the surgeon already attempts to minimize $F$ by injecting with the least force possible, $F$ becomes minimally variable. With a fixed needle size chosen using the aforementioned rationale, pressure can be minimized by distributing the same amount of force over a larger surface area of the syringe plunger. We advocate using a 10-cc syringe to minimize the injection pressures while maintaining adequate syringe control.

The appropriate sedation method should be chosen after consultation with the anesthesiologist. American Society of Anesthesia guidelines support the ingestion of clear liquids in children up to 2 hours before surgery because this does not predispose to aspiration. Preoperative euvolemia will minimize the decrease in mean arterial pressure during deep anesthesia and maximize resistance to any retrograde flow during injection.

Knowledge of the periorbital arterial architecture can be used to minimize the chances of canalization of major vessels. The eyelids have a rich anastomotic vascular supply. Medially, the upper eyelid is supplied by the medial palpebral artery, which arises from the main trunk of the ophthalmic artery, and laterally by the lateral palpebral artery, a branch of the lacrimal artery (Figs. 1 and 2). These arteries divide and anastomose centrally to form the superior marginal and peripheral arcades. The superior marginal arcade is located 2 to 3 mm above the eyelid margin within or just anterior to the tarsal plate. The superior peripheral arcade is located along the surface of Mueller’s accessory retractor at the superior border of the tarsus. Tumor position and extent primarily dictate injection approach, but the surgeon should consider these vascular relationships to avoid danger zones where needle orientation may lead to cannulation of larger regional vessels.

With injections around the tarsus, we recommend using a vertical approach for injections over the span of the tumor. This keeps the needle oriented 90 degrees from the peripheral and marginal arcades, minimizing cannulation risk for the largest vessels in this region. The needle parallels the smaller bridging vessels that are unlikely to be cannulated. When horizontal positioning is necessary (eg, for tumors much longer in width than height), the needle is oriented parallel to and in the direction of highest forward flow, away from the supraorbital notch (Figs. 2 and 3). Once positioned, the surgeon should draw back on the needle to look for blood aspiration before initiating the injection. Should blood aspirate into the syringe, indicating that it is located in a vessel, the surgeon should reposition the needle before injecting.

In cases where a temporal approach is necessary (eg, mass near the medial canthus), pressure by an assistant’s finger over the supraorbital notch can protect the vessels in this area and prevent retrograde flow (Fig. 4). The pressure occludes or decreases the luminal size to prevent retrograde flow. When the compression is released, a sudden high arterial flow occurs, flushing out any diluents in the arterial lumen. Should the artery be patent while compressed, the Venturi effect dictates that any decrease in luminal size is associated with an increase in flow velocity, thereby providing further resistance to retrograde flow. Direct compression of the tumor during or after the injection should be avoided to minimize pressure transmission into the arterial system.

Limiting the amount of corticosteroid injected at
any specific location can help prevent sufficient suspension from reaching the central retinal artery by a transient retrograde flow. The surgeon starts with the needle in one edge of the tumor and directs it through the central core of the lesion until reaching the distal border. Gentle injection while slowly withdrawing the needle ensures only transient cannulation of an arteriole should it occur, provides an even distribution of corticosteroid throughout the tumor, and reduces injection pressure at the tip of the needle by minimizing accumulation of solution at the injected area. The surgeon should limit the total amount of suspension injected. We recommend a total suspension of less than 1.5 cc. This amount is supported by other authors based on the amount of suspension needed to fill the interstitium and vascular spaces of an average-sized vascular tumor.13,14 Total injection volumes in the three reported cases of CRAO following intralesional capillary hemangioma treatment were 1.5, 2.4, and 3.5 cc.5-7

Pharmacologic properties of the chosen corticosteroid may play a role in vascular embolization. Corticosteroid injections are effective for treatment of spinal pain and, similarly, there have been reports of regional embolization associated with hypersensitivity and allergic reactions after intramuscular and intra-articular injections,21 but their relationship to corticosteroid embolism has not been defined.

Immediate indirect ophthalmoscopy to detect a CRAO is important because short periods of ischemia can result in irreversible retinal damage.22 Diagnosis and treatment of injection-related CRAO have been described.7 Given the limited number of reported cases of CRAO following injections, the significance of having no CRAO after 54 injections is uncertain. We acknowledge the absence of CRAO in this series could be due to chance rather than the described injection technique. Although the incidence of this devastating complication may be low, the steps outlined in this injection protocol were based on the current understanding of purported factors contributing to retrograde embolization, and were designed to incorporate added safety measures to further minimize its occurrence. This manuscript is the first to highlight the potential importance of orienting the needle parallel or perpendicular to the periocular major arteries to avoid direct cannulation and inadvertent injection of steroid against the forward blood flow of the vessel.

Although the study size was small, we believe this injection protocol should theoretically reduce the retrograde vascular occlusion risk by addressing the anatomic, physiologic, and pharmacologic factors contributory to embolization. Validation of the effectiveness of this injection method in an uncommon condition will require additional clinical studies with a standardized protocol, pooling of data from participating clinical centers, and careful monitoring of adverse events.

REFERENCES