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Original Article

# The value of color Doppler imaging and intralesional steroid injection in pediatric orbital capillary hemangioma

Yifeng Ke [a,*], Rui Hao [b], Yanjin He [a], Eric S. Tam [c], Xiaorong Li [a]

[a] *Tianjin Medical University Eye Hospital, Tianjin, China*
[b] *Tianjin Eye Hospital, Tianjin Key Laboratory of Ophthalmology and Visual Science, Tianjin Eye Institute, Clinical College of Ophthalmology Tianjin Medical University, Tianjin, China*
[c] *Department of Ophthalmology and Vision Sciences, University of Toronto, Toronto, Canada*

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**Abstract**

*Background*: To evaluate color Doppler imaging (CDI) as the primary imaging modality in the diagnosis of pediatric orbital capillary hemangioma.
*Methods*: This is a retrospective study of 36 consecutive cases of orbital capillary hemangiomas between January 2006 and July 2011. Data on demographic details, clinical findings, gray-scale ultrasonography, CDI characteristics, treatment, and follow-up period were reviewed.
*Results*: The mean age of onset was 7 weeks. Twenty-nine (81%) lesions presented as eyelid masses, whereas seven (19%) presented as exophthalmos. Nineteen (53%) tumors were located on the upper eyelid, seven (19%) on the lower eyelid, six (17%) in the medial canthus, and one on both upper and lower eyelids. Ultrasonography depicted a heterogeneous, well-defined, irregular tumor with a low or moderate echogenicity. All lesions presented with abundant color blood flow on CDI. The intralesional blood flow had a mean peak systolic velocity of 37.5 ± 24.5 cm/second, and a mean resistance index of 0.69 ± 0.16, representing a shift in the pulse Doppler toward high velocity and high resistance. After a single intratumoral injection of betamethasone, 18 cases (50%) resolved. Additionally, 15 (42%) and four (11%) cases resolved after two injections and three injections, respectively. Only three (8%) masses persisted after three injections within the follow-up period.
*Conclusion*: The blood flow characteristics of CDI play a vital role in the differentiation of orbital capillary hemangiomas from other orbital lesions. The availability and lack of adverse effects of CDI enable its utilization in the early clinical diagnosis of pediatric orbital capillary hemangioma.


*Keywords:* capillary hemangioma; color Doppler imaging; orbital; pediatric; ultrasonography

## 1. Introduction

Capillary hemangiomas are benign vascular neoplasms that affect up to 5% of infants in the 1st year of life. Often referred to as infantile hemangiomas, or strawberry hemangiomas, these distinct vascular lesions are the most common eyelid and orbital tumors of infancy. The morbidity is 1–2% in neonates.[1] It occurs more commonly in premature and low-birth-weight babies.[2]

The natural history of capillary hemangioma is rapid growth in the 1st year of life with later spontaneous gradual involution over several years.[3] It is difficult to discriminate the capillary hemangioma from other fast-growing pediatric neoplasms. The diagnosis of capillary hemangioma is usually based on the clinical presentation, and imaging modalities such as computed tomography (CT) and magnetic resonance

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* Corresponding author. Dr. Yifeng Ke, Tianjin Medical University Eye Hospital, 251, Fukang Road, Nankai, Tianjin 300384, China.
*E-mail address:* keyifeng2003@163.com (Y. Ke).

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imaging (MRI). However, most soft-tissue masses have no specific characteristics that are visible on MRI to determine whether they are benign or malignant.[4] Color Doppler imaging (CDI) is recently described as a reliable, noninvasive, nonradiating, and inexpensive imaging tool for diagnosing vascular tumors in children.[5,6] However, reports about the applications of CDI in periocular capillary hemangiomas are sparse.[7,8] In this study, we review 36 cases of pediatric orbital capillary hemangioma and describe the applications of CDI as the primary imaging modality in the diagnosis of the capillary hemangioma.

## 2. Methods

This retrospective study comprised 36 children with orbital capillary hemangiomas seen between January 2006 and July 2011 at our hospital. The Ethics Committee of Tianjin Medical University (Tianjin, China) approved the study, and all participants were informed about the scope of the study and gave their written informed consent.

In all patients, we based the diagnosis of an orbital capillary hemangioma on the age at onset, the clinical presentation and demonstration of typical characteristics on CDI,[4,9] whereas other imaging modalities such as CT or MRI were used according to the clinical appearance.[8]

All the studied children underwent a comprehensive ophthalmologic examination upon presentation. The clinical appearance was characterized based on the location, size, and color of the lesion, ocular motility, ptosis, intraorbital pressure, exophthalmos, and response to Valsalva maneuver (it resulted in lesion enlargement and surface color changes).

All patients had color Doppler ultrasonography (US) including color Doppler flow imaging (CDFI) and color Doppler power imaging (CDPI) for confirmation of the diagnosis. All of the patients received CDI examination by one experienced sonographer, using a Philips IU22 scanner (Royal Philips, Amsterdam, Netherlands) with a 5–12 MHz linear-array transducer. Each child was sedated with diazepam (0.5 mg/kg), then placed in a supine position, with closed eyes covered with sterile coupling gel. The transducer was placed directly on the eyelid. First, using gray-scale US, the findings were characterized according to tumor volume, shape, position, and echogenicity. US revealed variable internal reflectivity: high reflectivity from fibrous septae, moderate echoes from vascular channels, and low reflectivity from areas of endothelial proliferation.[10] Later, CDFI was used, and the results were recorded according to the position and color blood flow signals. After that, pulse Doppler examination was performed, with the transducer placed where the fastest blood velocity was detected, with the acoustic beam aligned parallel to the direction of the blood vessel. The findings were recorded as peak systolic velocity (PSV) and vascular resistance index (RI). Finally, the CDPI was assessed.

According to the analysis of the color blood flow, the cases were divided into four grades: A = no color blood flow (no color blood flow signals after checking the whole mass); B = moderate color blood flow (1–4 color blood flow signals were detected after checking 1 random plane of the mass); C = abundant color blood flow (more than 4 color blood flow signals were detected after checking 1 random plane of the mass, but they were also countable); D = suffuse color blood flow (uncountable color blood flow signals in the whole mass). The blood flows of all cases were evaluated on the basis of this criterion.

MRI scans were performed on a 1.5-T MR system (Siemens, Erlangen, Germany). The imaging protocol included T1-weighted axial, sagittal, and coronal fat-suppressed imaging, T2-fast spin–echo (SE), axial, sagittal, and coronal fat-suppressed imaging, and T1-weighted SE imaging with gadolinium injection. CT scanning was used in some cases because of limited access to MRI. Slice thickness was 3 mm. Sixteen MRI scans were performed on a 1.5-T MR system. Ten patients had CT scanning because of limited access to MRI.

All patients received intralesional injections for cosmetic reasons upon request by their parents. After an intratumoral injection of betamethasone (3.5–7 mg), dexamethasone (2.5 mg), and lidocaine (10 mg), the lesion was compressed with padding and bandage for 2 hours. If the lesion did not resolve within 1 month, additional injections were administered. The interval between injections was 4 weeks, and all patients had a predetermined maximum of three injections to minimize corticosteroid side effects. Each case was followed up for 6 months or more and received CDI examination during the follow-up period.

## 3. Results

The demographic details and clinical findings of 36 patients are summarized in Table 1. Of the thirty-six cases reviewed in this study, 17 (47%) were male and 19 (53%) were female. There were twenty (55%) right eyes and 16 (45%) left eyes. The mean age at onset was 7 weeks (range 0–24 weeks). Clinically, 29 (81%) cases presented with eyelid swelling and seven (19%) presented with exophthalmos. Twenty-one (58%) cases had positive Valsalva maneuver. We also found nine (25%) cases with brightly erythematous eyelid surfaces, referred to as strawberry appearance. Nineteen (53%) lesions were located on the upper eyelid, seven (19%) on the lower eyelid, six (17%) in the medial canthus, and in one case on both upper and lower eyelids. Extraocular movement was restricted in five (14%) cases, and seven (19%) cases had high intraorbital pressure.

All patients received CDI examination. The CDI findings of 36 patients are summarized in Table 2. In 15 cases (42%), US depicted the lesions in the subcutaneous tissue of the eyelid. Eighteen (50%) lesions were located in the periocular tissue and extended to the posterior of orbit, and three (8%) lesions were located in the retrobulbar space. Twenty lesions (56%) were well-defined masses, whereas 16 masses (44%) had indistinguishable borders. Twenty lesions (56%) were irregular, whereas five (14%) lesions and six (17%) lesions were circular and flat, respectively. Compared to the periorbital

Table 1
Demographic details and clinical findings of 36 patients with pediatric orbital capillary hemangiomas.

| Patient no. | Sex/age (wk) | Location of lesion | Symptoms | Number of injections | Effect of treatment | Follow-up (mo) |
|---|---|---|---|---|---|---|
| 1 | F/6 | Right upper eyelid | Eyelid swelling | 1 | Resolved | 14 |
| 2 | M/4 | Left medial canthus | Eyelid swelling | 1 | Resolved | 9 |
| 3 | F/6 | Right lower eyelid | Eyelid swelling | 2 | Resolved | 6 |
| 4 | F/0 | Left upper eyelid | Eyelid swelling | 1 | Resolved | 12 |
| 5 | M/0 | Left medial canthus | Eyelid swelling | 1 | Resolved | 12 |
| 6 | F/4 | Right medial canthus | Eyelid swelling | 2 | Resolved | 6 |
| 7 | M/8 | Right upper eyelid | Eyelid swelling | 1 | Resolved | 8 |
| 8 | F/4 | Right upper eyelid | Eyelid swelling | 2 | Resolved | 9 |
| 9 | F/12 | Right upper eyelid | Eyelid swelling | 3 | Unsolved | 18 |
| 10 | F/4 | Left upper eyelid | Eyelid swelling | 2 | Resolved | 6 |
| 11 | F/8 | Left medial canthus | Eyelid swelling | 2 | Resolved | 7 |
| 12 | F/0 | Left medial canthus | Eyelid swelling | 3 | Unsolved | 24 |
| 13 | F/3 | Right upper eyelid | Exophthalmos | 1 | Resolved | 8 |
| 14 | M/6 | Right upper eyelid | Eyelid swelling | 3 | Resolved | 24 |
| 15 | F/8 | Left upper eyelid | Exophthalmos | 2 | Resolved | 6 |
| 16 | M/2 | Right lower eyelid | Eyelid swelling | 1 | Resolved | 7 |
| 17 | F/16 | Left upper eyelid | Eyelid swelling | 2 | Resolved | 10 |
| 18 | F/11 | Left upper eyelid | Eyelid swelling | 1 | Resolved | 12 |
| 19 | F/11 | Left retrobulbar | Exophthalmos | 1 | Resolved | 8 |
| 20 | M/4 | Left lower eyelid | Exophthalmos | 1 | Resolved | 12 |
| 21 | M/8 | Left lower eyelid | Eyelid swelling | 2 | Resolved | 9 |
| 22 | F/4 | Right lower eyelid | Eyelid swelling | 1 | Resolved | 7 |
| 23 | M/8 | Right upper eyelid | Eyelid swelling | 2 | Resolved | 6 |
| 24 | M/9 | Right upper eyelid | Eyelid swelling | 1 | Resolved | 8 |
| 25 | M/24 | Right upper eyelid | Eyelid swelling | 1 | Resolved | 12 |
| 26 | M/24 | Right upper eyelid | Eyelid swelling | 1 | Resolved | 15 |
| 27 | M/0 | Left upper eyelid | Eyelid swelling | 1 | Resolved | 7 |
| 28 | M/0 | Left upper eyelid | Eyelid swelling | 2 | Resolved | 12 |
| 29 | F/7 | Right retrobulbar | Exophthalmos | 2 | Resolved | 24 |
| 30 | M/23 | Right lower eyelid | Eyelid swelling | 2 | Resolved | 12 |
| 31 | F/4 | Left retrobulbar | Exophthalmos | 2 | Resolved | 13 |
| 32 | M/0 | Right upper eyelid | Eyelid swelling | 1 | Resolved | 10 |
| 33 | F/11 | Right medial canthus | Exophthalmos | 3 | Unsolved | 18 |
| 34 | F/6 | Right lower eyelid | Eyelid swelling | 2 | Resolved | 11 |
| 35 | M/0 | Left upper and lower eyelid | Eyelid swelling | 1 | Resolved | 9 |
| 36 | M/12 | Right upper eyelid | Eyelid swelling | 1 | Resolved | 9 |

subcutaneous fat or the orbital fat, the hemangiomas showed a hypoechoic signal in 10 of our cases, whereas medium- and high-internal-echogenicity lesions were observed in 19 cases and seven cases, respectively. The echo was heterogeneous in 31 cases (86%), but homogeneous in five cases (14%). There were no calcifications in any of the masses. The mean volume of hemangioma was 2.89 ± 2.01 $cm^3$ (range 0.7–12 $cm^3$). CDFI illustrated numerous blood vessels within the masses. According to the blood flow criteria described in Methods, six lesions had abundant color blood flow (C grade), and 30 lesions had suffuse color blood flow (D grade). No lesions were classified in other grades. The angle-corrected pulse Doppler examination demonstrated a mean PSV of 37.5 ± 24.5 cm/second (range 9.17–119 cm/second). The mean RI was 0.69 ± 0.16 (between 0.37 and 0.92). CDPI showed numerous power signals in the lesion (Figs. 1 and 2).

After one injection of betamethasone, 18 cases (50%) resolved. Additionally, 15 cases (42%) and four cases (11%) resolved after two injections and three injections, respectively (Table 1). Only three masses persisted after three injections within the follow-up period. The curative ratio was 92%. During the follow-up period (mean 11 months, range 6–24 months), no cured cases recurred. The side effect of injection was bruising at the site of injection, which disappeared within 2 weeks. No other treatment-related complications were found in the follow-up period. The reexamining CDI showed no or scarce blood flow in all 33 (92%) cured patients, whereas abundant blood flow was found in the remaining three (8%) patients. In all of these three cases, the lesion size decreased considerably and blood flow weakened after the first injection. However after the second injection and third injection, the tumor size did not reduce further, and on the contrary, the blood flow increased in two cases.

## 4. Discussion

Our study demonstrates that capillary hemangiomas have characteristic findings on CDI that may play an important role in confirming the clinical diagnosis. The CDI technique is valuable in discriminating between capillary hemangioma and other pediatric tumors by demonstrating the presence or absence of blood flow in the tumor.

Table 2
Grayscale ultrasound and color Doppler imaging findings in 36 patients with pediatric orbital capillary hemangiomas.

| Patient no. | Tumor volume ($cm^3$) | Contour | Echogenicity | PSV (cm/s) | RI |
|---|---|---|---|---|---|
| 1 | 2.5 | Distinct | Medium | 40.0 | 0.69 |
| 2 | 2.3 | Distinct | Hypo | 38.5 | 0.70 |
| 3 | 6 | Indistinguishable | Hypo | 119.0 | 0.80 |
| 4 | 12 | Indistinguishable | Hypo | 15.6 | 0.69 |
| 5 | 1.6 | Distinct | Medium | 24.6 | 0.77 |
| 6 | 2.2 | Indistinguishable | Hyper | 93.7 | 0.83 |
| 7 | 3 | Indistinguishable | Medium | 10.2 | 0.37 |
| 8 | 3.5 | Distinct | Hypo | 16.0 | 0.56 |
| 9 | 1.8 | Distinct | Medium | 15.0 | 0.91 |
| 10 | 4.5 | Distinct | Medium | 28.2 | 0.82 |
| 11 | 2.2 | Distinct | Hyper | 9.17 | 0.64 |
| 12 | 2.5 | Indistinguishable | Medium | 54.3 | 0.61 |
| 13 | 1.8 | Distinct | Medium | 30.9 | 0.73 |
| 14 | 1.7 | Indistinguishable | Medium | 29.3 | 0.79 |
| 15 | 4.8 | Indistinguishable | Hypo | 71.4 | 0.92 |
| 16 | 1.7 | Distinct | Medium | 28.0 | 0.69 |
| 17 | 1.2 | Distinct | Hypo | 10.5 | 0.45 |
| 18 | 2.4 | Distinct | Medium | 90.6 | 0.49 |
| 19 | 1.5 | Distinct | Hypo | 40.0 | 0.80 |
| 20 | 0.7 | Indistinguishable | Medium | 14.6 | 0.71 |
| 21 | 3 | Distinct | Medium | 19.7 | 0.77 |
| 22 | 4.2 | Indistinguishable | Hyper | 21.2 | 0.68 |
| 23 | 2.4 | Distinct | Hyper | 19.7 | 0.82 |
| 24 | 5.6 | Indistinguishable | Medium | 69.7 | 0.39 |
| 25 | 0.7 | Distinct | Hyper | 21.1 | 0.75 |
| 26 | 3.2 | Indistinguishable | Medium | 28.0 | 0.69 |
| 27 | 3.6 | Indistinguishable | Hyper | 52.4 | 0.85 |
| 28 | 2.1 | Indistinguishable | Medium | 28.4 | 0.61 |
| 29 | 1.8 | Distinct | Medium | 43.2 | 0.91 |
| 30 | 3.8 | Distinct | Hypo | 31.2 | 0.88 |
| 31 | 1.9 | Indistinguishable | Hypo | 40.5 | 0.37 |
| 32 | 1.6 | Indistinguishable | Medium | 28.7 | 0.64 |
| 33 | 1 | Distinct | Medium | 38.8 | 0.78 |
| 34 | 3 | Indistinguishable | Medium | 53.6 | 0.68 |
| 35 | 3.4 | Distinct | Hypo | 41.6 | 0.56 |
| 36 | 3 | Distinct | Hyper | 16.3 | 0.43 |

PSV = peak systolic velocity; RI = resistance index.

According to the US and CDI examinations, most lesions were located in the subcutaneous tissue of the eyelid. Although some lesions extend to the posterior orbit, masses growing independently in the retrobulbar orbit were scarce (3 cases). The US showed a heterogeneous, well-defined, irregular tumor with a low or medium internal echogenicity. We consider such appearance is due to the heterogeneous components of the lesions such as differentiating endothelial cells, numerous vascular channels, and mast cells.[11]

Capillary hemangiomas can be divided into three types on the basis of the lesion positions on CDI. The first type is limited to a superficial plaque in the eyelid. The blood flow is concentrated on the surface of the skin and has abundant blood flow in the CDI. In the second type, the hemangioma invades the deeper layers of the eyelid and periocular tissue. Meanwhile, the abundant blood flow signals extend to the orbit in the extraconal space and are characterized as high-flow vascular lesions on CDI. These subdermal lesions present with a bluish/purplish hue and Valsalva maneuver. Valsalva maneuver can result in enlargement and surface color changes, helping to differentiate them from other hemangiomas.[12] In the third type, hemangiomas invade both the dermis and intraorbital space. In these cases, the symptoms may be severe, and CDI shows high blood flow in the whole lesion.

The CDI demonstrate abundant color blood flow that is centralized in most lesions. The pulse Doppler examination in this study shows that the mean PSV was 37.5 ± 24.5 cm/second, and the mean of RI was 0.69 ± 0.16. Other reports illustrated that hemangiomas had variable blood velocity in feeding vessels with PSV ranging between 15.2 cm/second and 52 cm/second[7,9] and a mean RI of 0.48–0.54.[5,13] The PSV in our study is within the reported range. However, the RI in our study is higher than those in other reports. We considered that the differences were attributable to interoperator differences in the choice of assessing different pulse blood vessels and a different angle of the blood flow with acoustic beam. In contrast with the RI of other pediatric tumors such as rhabdomyosarcoma, the RIs found in our cohort were higher, and the pulse Doppler shift demonstrated high velocity and high resistance.[5]

These typical characteristics of CDI and pulse Doppler shift in capillary hemangioma are a helpful aid in the differential diagnosis from other periorbital tumors in the pediatric population. Consequently, given the noninvasive nature and easy accessibility of this imaging modality, we regard CDI as the primary imaging modality for orbital capillary hemangiomas, where typical lesions can be diagnosed directly. However, a clear diagnosis may be elusive when lesions are atypical and when all or part of the lesion lies deep in the orbit and cannot be clearly defined on physical examination. Atypical lesions are difficult to distinguish from vascular malformations and pediatric tumors such as rhabdomyosarcoma and arteriovenous malformations (AVMs).[14]

The clinical presentations of rhabdomyosarcoma are similar to those of capillary hemangioma, especially when they are singly located in the retrobulbar orbit. Both present at a young age, with a rapidly evolving unilateral proptosis and eyelid swelling. Because MRI and CT cannot exactly discriminate them,[4] US and CDI are the preferred imaging modalities. In rhabdomyosarcoma, gray-scale US shows a nodular lesion with low and irregular internal reflectivity, whereas the CDI shows abundant blood flow. By contrast, the blood flow signal of rhabdomyosarcoma is dispersed, and PSV and RI are lower than in capillary hemangioma.[5] An experienced examiner can demonstrate the pattern of blood flow in rhabdomyosarcoma to be consecutive branching flow, which differs from the abundant blood flow in capillary hemangioma, which may be more obvious on CDPI.[15]

Another lesion to be distinguished from capillary hemangioma is AVM, which also presents at a young age with swollen eyelid and rapidly progressing exophthalmos. On US, the AVMs appear as heterogeneous lesions with pulsating feeding vessels large enough to be seen on gray scale; the CDI technique demonstrates mixed arterial and venous flow with

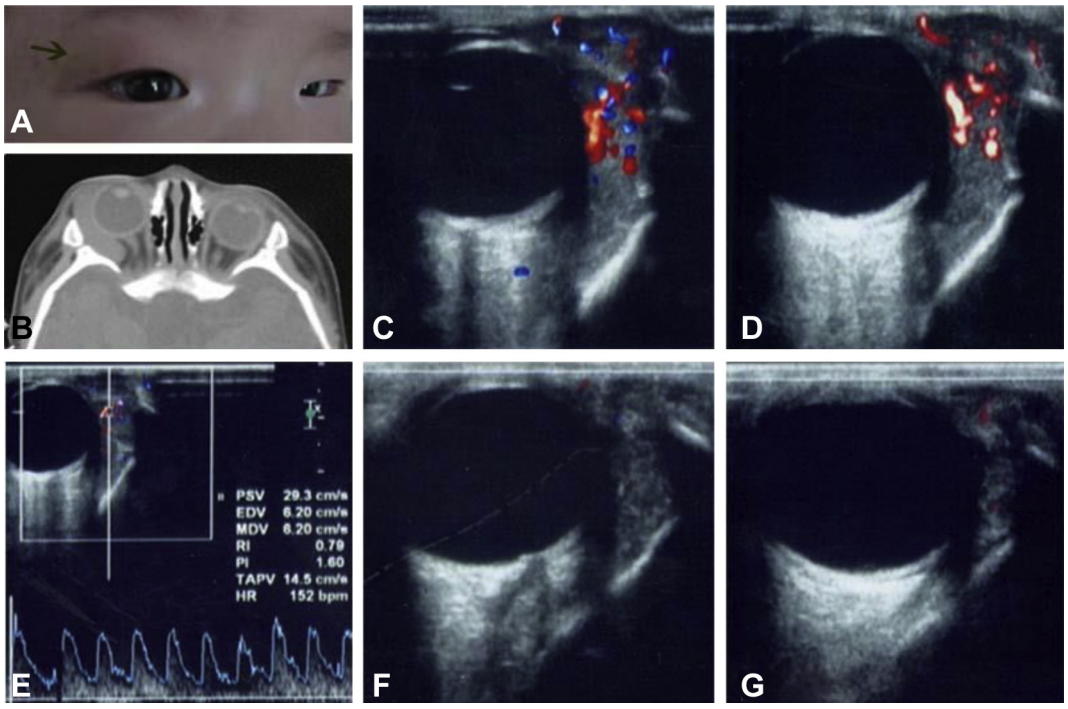


Fig. 1. (A) A 6-month-old male patient shows temporal upper eyelid subdermal lesions presenting with bluish/purplish hue (arrow). (B) Computed tomography (CT) axial image shows infraorbital, extraconal soft-tissue-density masses. (C, D) Color Doppler flow imaging (CDFI) and color Doppler power imaging (CDPI) show the high-flow vascular lesion. (E) The pulse Doppler shifting shows high speed and high resistance of blood flow; the resistance index (RI) is 0.79. (F) CDFI 4 months after the third intralesional injection shows that the lesion has almost completely disappeared. (G) CDPI 4 months after the third intralesional injection shows that there is no signal on the CDPI.

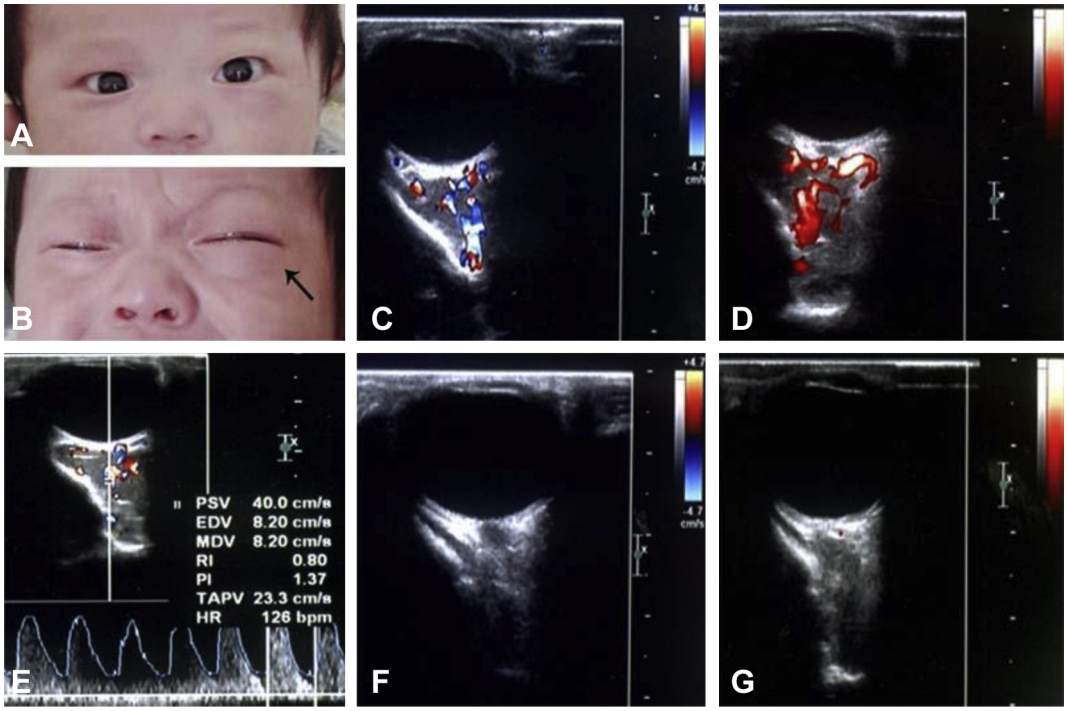


Fig. 2. An 11-month-old female patient with retrobulbar capillary hemangioma. (A) The infant with a 10-day history of left eye exophthalmos. (B) Positive Valsalva maneuver resulting in lesion enlargement (arrow). (C) Ultrasonography shows a lesion with irregular contour, medium echogenicity and heterogeneity. CDFI demonstrates an abundant red-blue blood flow signal. (D) CDPI illustrates heavy vascularization in the lesion. (E) Pulse Doppler shifting shows a high speed and high resistance of blood flow; the RI is 0.8. (F) CDFI of the same patient 1 month following intratumoral injection, demonstrating no blood flow. (G) CDPI 1 month after intratumoral injection, again with no signal on the CDPI. CDFI = color Doppler power imaging; CDPI = color Doppler power imaging; RI = resistance index.

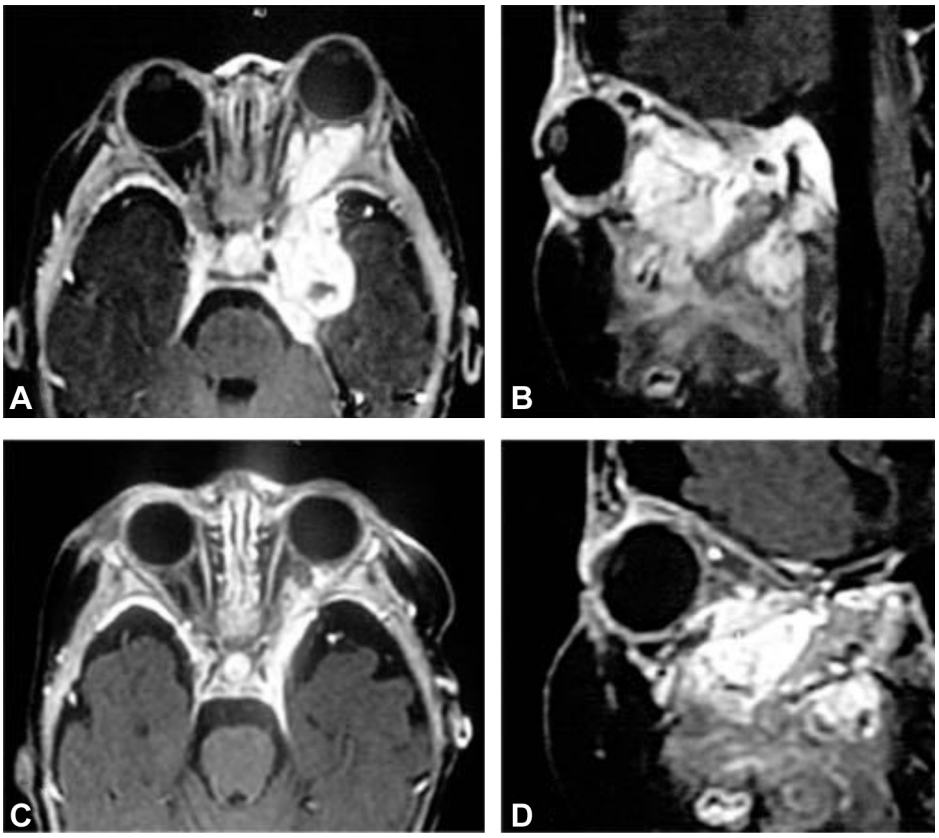


Fig. 3. Magnetic resonance imaging (MRI) of an 11-month-old female patient. (A) Axial and (B) sagittal fat-suppressed T1-weighted spin–echo (SE) with gadolinium injection. The imaging shows the lesion has invaded into the whole left orbital cavity, pterygopalatine fossa, middle cranial fossa, and intracalvarium. MRI of the same patient 2 weeks after intralesional injection with corticosteroid: (C) axial and (D) sagittal fat-suppressed T1-weighted SE with gadolinium injection show the lesion has disappeared almost completely.

high vessel density and high PSV with multiple sites of arteriovenous shunting.[16] This is in contrast with capillary hemangioma, where the RI is higher.[1]

Atypical lesions are also difficult to distinguish from the posterior orbital tumors. Some studies indicate that ultrasound and CDI are of limited value in evaluating posterior orbital tumors because of the limited penetration of high-frequency sound waves into the deeper tissues,[8,17] in which case MRI or CT may be preferred.[8] In our study, we found CDI was also extremely valuable in the diagnosis of posterior orbital entities. For instance, in patient 19, the lesion was located in the posterior orbit, with presentation similar to that of rhabdomyosarcoma. The MRI scan showed that the retrobulbar lesion invaded into the pterygopalatine fossa, middle cranial fossa, and the brain. Both MRI and clinical presentations made it difficult to distinguish this lesion from rhabdomyosarcoma (Fig. 3A and B). However, the CDI showed characteristics of a high-flow posterior orbital vascular lesion. Finally, 2 weeks after an intralesional injection of corticosteroid, the lesion had almost completely disappeared (Fig. 3C and D). The limited penetration by ultrasound seemingly did not impact the diagnosis of posterior capillary hemangioma by CDI in this case. Because of the small sample size of our study ($n = 3$), this observation will require further study. In the past, diagnosing capillary hemangioma was based on the typical clinical presentations and imaging modalities such as CT and MRI. However, both CT and MRI have limitations, including intravenous contrast injection and comparatively low availability owing to high cost (MRI). The exposure to radiation with CT is especially of concern in pediatric patients.

The use of intralesional corticosteroids to induce involution of capillary hemangiomas was first introduced in 1982.[18] Since then, steroids have remained the first-line treatment for infantile hemangioma in the vast majority of cases.[19] In our research, 33 cases (92%) were cured after steroid injections. Meanwhile, adverse effects have not been found with intralesional steroids, in particular, skin changes, adrenal-related changes and retinal artery occlusion.[20]

Overall, US and CDI are cost-efficient, rapidly executed, noninvasive, and nonradiative techniques that can help establish the correct diagnosis.[9] They are also well tolerated by children.[21] The ready availability and lack of adverse effects of CDI thus enable their use as primary tools in the clinical diagnosis of capillary hemangioma.

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