Imaging features of Color Doppler Ultrasound, computed tomography and computed tomography dacryocystography in lacrimal sac space-occupying lesions

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Article

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Abstract

Purpose: Lacrimal sac space-occupying lesions (SOLs) are rare and sometimes life-threatening disorders, often misdiagnosed in clinical practices. This study aimed to observe the imaging features of Color Doppler ultrasound (CDU) and computed tomography (CT) or computed tomography dacryocystography (CT-DCG) in different types of lacrimal sac SOLs.

Methods: This retrospective case series study included 21 patients with lacrimal sac SOLs who underwent lacrimal sac surgery between January 2018 and March 2022. The imaging features of CDU and CT or CT-DCG in these patients extracted from the examination cloud system were observed and analyzed.

Results: 21 patients with lacrimal sac SOLs completed preoperative CDU and CT or CT-DCG examination. CDU showed abnormal lacrimal sac imaging in all cases of SOLs (21/21, 100%), while CT or CT-DCG showed abnormal imaging in 20 cases (20/21, 95.2%). CDU could detect the blood flow signals in all types of space-occupying lesions except mucocele and mucoprotein concretion. Among them, polyps had characteristic imaging changes on CDU and CT-DCG. The mucoceles and mucoprotein concretions had characteristic imaging changes on CDU, which could provide more information for differential diagnosis.

Conclusions: CDU can observe the morphology and internal blood flow signals of lacrimal sac SOLs. CT or CT-DCG has advantages in observing structural damage around the lacrimal sac mass. Therefore, CDU may be used as a routine examination to exclude lacrimal sac SOLs before DCR in the absence of preoperative CT or CT-DCG.

Introduction

Dacryocystitis and nasolacrimal duct obstruction are fairly common disorders in adults and are common causes of epiphora. Dacryocystorhinostomy (DCR) is a widely used and effective treatment for dacryocystitis and nasolacrimal duct obstruction. Among these cases, some patients have space-occupying lesions (SOLs) in the lacrimal sac area, such as mucoprotein concretions, mucoceles, granulomas, and even tumors[1–4]. DCR can be performed without affecting in patients with mucoprotein concretions, mucoceles, and granulomas[1, 3]. However, a more complex treatment plan must be adopted for patients with lacrimal sac tumors. In addition, the disease's severity and the treatment complexity should be informed prior to surgery since more than 55% of lacrimal sac tumors are malignant[4–7]. Therefore, preoperative diagnosis and identification of lacrimal sac SOLs are essential.

A computed tomography dacryocystography (CT-DCG) of the lacrimal drainage system is always considered effective in recognizing lacrimal sac SOLs, mainly manifest as lacrimal sac filling defects due to SOLs[4, 5]. Computed tomography (CT) is also an important and commonly used method in aiding diagnosis of lacrimal sac SOLs[8–10]. However, a previous web-based questionnaire study had reported that the proportion of CT examinations before DCR was less than 5%, and other imaging examinations were even less [11]. Therefore, due to a lack of imaging examinations and the symptoms similar to dacryocystitis and nasolacrimal duct obstruction, the lacrimal sac SOLs does not get identified before DCR[5, 6, 8, 9, 12–14]. However, Color Doppler ultrasound (CDU) applied in lacrimal system diseases can clearly show the two-
dimensional structures of the lacrimal sac and surrounding tissues with normal and abnormal blood flow conditions[15, 16]. Furthermore, CDU has been used to observe lacrimal gland tumors[17]. In addition, CDU has the advantages of being radiation-free, easy to operate, and economical. Therefore, CDU may become an important tool in detecting lacrimal sac SOLs. Currently, there is no study on the color Doppler imaging changes of lacrimal sac SOLs. Thus, this study has attempted to assess the CDU and CT-DCG characteristics of the lacrimal sac SOLs.

Materials And Methods

A retrospective analysis was performed on the patients with lacrimal sac SOLs in the Eye and Optometry Hospital Affiliated with Wenzhou Medical University from January 2018 to March 2022. The study followed the tenets of the Declaration of Helsinki and was approved by the institute ethics committee. Furthermore, the institute ethics committee waived informed consent for extracting data from hospital records without revealing the personal identity of the participants. Patients who had completed CDU and CT-DCG or CT examination 2 weeks before surgery and were diagnosed with lacrimal sac SOLs according to intraoperative observation and pathological results were included in this study. A total of 33 cases of lacrimal sac SOLs were found. However, preoperative ultrasound or CT examination was absent in 12 of them. Finally, 21 patients were enrolled in this study. We compared preoperative CDU and CT-DCG or CT examination in these 21 patients based on the pathological and clinical diagnosis. In addition, we recorded the success rate of DCR and the recurrence rate of lacrimal sac SOLs at the follow-up.

CDU was performed using the Vinno G60 system (Vinno technology, Suzhou, China) using an electronic linear probe with a central frequency of 16 MHz. All patients were examined in the supine position. First, the skin corresponding to the lacrimal fossa region was coated with a disinfectant coupling agent. Next, the probe was placed over the skin and moved in transverse and cranio-caudal directions. A qualitative assessment of the size of the lacrimal sac, its content, and surrounding structures was first performed in B-mode (frequency – 16 MHz). Then, CDU (frequency – 10 MHz) was used to analyze the existence of blood supply in the lacrimal sac SOLs. The CT-DCG images were acquired after injection of a water-soluble iodinated contrast medium (Compound Maglumine Diatrizoate, 370 mg/mL) through the lower lacrimal punctum, with the layer thickness from 1 to 2mm.

The basic information of all patients was recorded as follows: age, sex, side of involvement, duration of epiphora, and history of lacrimal system intervention. All the SOLs obtained during surgery were sent for pathological examination. All patients were followed up for more than 1 month.

Results

According to intraoperative and pathological findings, among the 21 lacrimal sac SOLs, 8 lacrimal sac polyps, 6 mucoceles, 3 mucoprotein concretions, 1 inflammatory granuloma complicated with mucoprotein concretion, 1 inflammatory granuloma, and 2 tumors were detected. The basic information of all patients is presented in Table 1. The CDU showed abnormal lacrimal sac imaging in all cases of SOLs (21/21, 100%), while CT or CT-DCG showed abnormal imaging in 20 cases (20/21, 95.2%). The CDU imaging features of
different types of lacrimal sac SOLs are summarized in Table 2. All patients underwent EEDCR except for two cases of tumor and one case of inflammatory granuloma. A total of 18 cases who underwent EEDCR were successful, and none recurred after surgery. The patient with melanocytic carcinoma was followed up for 1 month without recurrence and then lost the follow-up. One patient with squamous cell carcinoma showed no recurrence during the 9-month follow-up.

Table 1
Clinical and demographic characteristics of patients.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>53.2 ± 14.3 (range: 28 to 82)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease duration (months)</td>
<td>29.8 ± 23.4 (range: 2 to 108)</td>
</tr>
<tr>
<td>Follow up (months)</td>
<td>9.6 ± 4.5 (range: 1 to 23)</td>
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<tr>
<td>Right eye: Left eye</td>
<td>9:12</td>
</tr>
<tr>
<td>Male: female ratio</td>
<td>4:17</td>
</tr>
<tr>
<td>Diagnose</td>
<td>Number of cases</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Polyp</td>
<td>8</td>
</tr>
<tr>
<td>Mucocele</td>
<td>6</td>
</tr>
<tr>
<td>Mucoprotein concretion</td>
<td>3</td>
</tr>
<tr>
<td>Inflammatory granuloma</td>
<td>1</td>
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<tr>
<td>Inflammatory granuloma with concretion</td>
<td>1</td>
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<tr>
<td>Diagnose</td>
<td>Number of cases</td>
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<tr>
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<tr>
<td>Tumor</td>
<td>2</td>
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</tbody>
</table>

The results of conventional ultrasonography of 8 cases of lacrimal sac polyps showed moderate-signal echogenic solid masses in the lacrimal sac. In 8 cases (8/8, 100%), all the masses were round-like with clear and smooth edges and a uniform internal echo (Fig. 1A). In all cases, the base of the mass connected to the wall of the lacrimal sac was narrow (Fig. 1A). Color Doppler ultrasound showed that the 7 patients (7/8, 87.5%) had lined or dotted blood flow signal inside (Fig. 1B). In contrast, no blood flow signal was detected in 1 case (1/8, 12.5%) due to the small mass (the largest cross-section was about 1.5mm*1mm). CT-DCG showed a solid mass of soft tissue density in the lacrimal sac. The 7 cases (7/8, 87.5%) showed a round-like filling defect connected to lacrimal sac walls (Fig. 1C). No filling defect was observed in 1 case (1/8, 12.5%) due to the small mass. Smooth-surfaced spherical-like soft tissue was found during surgery in the lacrimal sac of all 8 patients (Fig. 1D).

Conventional ultrasonography of 6 cases of mucoceles showed moderate-intensity flocculation echoes in the lacrimal sac. A total of 4 cases (4/6, 66.7%) resembled an oval shape, and 2 cases (2/6, 33.3%) had a "hill"-like shape, narrow in the upper part and wide in the lower part (Fig. 2A, 2B). In all cases, the echoes gradually increased from top to bottom, and the changes were similar to "precipitation". In addition, the echoes of the posterior wall of the lacrimal sac were significantly enhanced (Fig. 2A, 2B). Color Doppler ultrasound showed that no blood flow signal was detected in the lacrimal sac in 6 patients (6/6, 100%) (Fig. 2C). The CT revealed a low-density soft tissue mass in the lacrimal sac (Fig. 2D). No solid mass was found during the surgery in any patient. Further, the probe could only enter the lacrimal sac from the common canaliculus after the sac was incised.

Conventional ultrasonography of 3 cases of mucoprotein concretions showed a moderate-hyperechoic solid mass in the lacrimal sac. In addition, all 3 cases (3/3, 100%) had oval-like shapes with clear but not smooth edges and uneven internal echoes. While 2 cases (2/3, 66.7%) had echo attenuation. 2 cases (2/3, 66.7%) of large concretions were attached to the wall of the lacrimal sac (Fig. 3A), and 1 case (1/3, 33.3%) of small concretion did not have contact to the lacrimal sac wall. The Color Doppler ultrasound showed no blood flow signal in 3 cases (3/3, 100%) (Fig. 3B). The CT-DCG of all 3 patients showed irregularly shaped filling defects with dense, soft tissue at the defect. Of which 2 cases with large concretions (2/3, 66.7%) were connected to the lacrimal sac wall, whereas 1 case with small concretion...
(1/3, 33.3%) was not connected to the lacrimal sac wall (Fig. 3C). In all 3 cases, mucopeptide concretions were completely removed during the operation (Fig. 3D).

Conventional ultrasonographic findings of inflammatory granuloma showed a moderate-hyperechoic solid mass with clear, non-smooth edges, irregular shape, and uneven internal echogenicity, with the base adhering to the sac wall. Color Doppler ultrasound showed abundant blood flow signals (Fig. 4A). The CT showed soft tissue mass in the lacrimal sac and nasolacrimal duct without obvious bone destruction (Fig. 4B). In this case, the lacrimal sac tumor was considered before surgery, and the lacrimal sac and nasolacrimal duct were resected during the surgery.

One inflammatory granuloma with concretion showed a solid mass with medium-high signal echoes, unclear edges, irregular shape, and uneven internal echogenicity. The bottom was connected to the lacrimal sac (Fig. 5A). The Color Doppler showed speckled blood flow near the sac wall (Fig. 5B). The CT-DCG showed extensive irregular soft-tissue filling defect with an uneven margin attached to the lacrimal sac wall (Fig. 5C). In addition, there was a filling defect of soft tissue not adjacent to the lacrimal sac wall (Fig. 5D). Granulomatous hyperplasia was observed on the wall of the lacrimal sac during surgery (Fig. 5E).

Two cases of lacrimal sac tumor showed a moderate solid mass by traditional ultrasonography. The 2 cases (100%) filled the entire lacrimal sac. While the melanocytic carcinomas had a clear border, the boundary of squamous cell carcinomas was unclear, and the echoes were not uniform in these 2 cases (Fig. 6A, 6B). The base of melanocytic carcinomas was widely attached to the sac wall. The squamous cell carcinomas filled the entire lacrimal sac, and the base could not be observed. The CDU showed scattered punctate blood flow signals in melanocytic carcinomas. However, more abundant blood flow signals were observed in squamous cell carcinomas (Fig. 6C, 6D). The CT results of both cases showed that the soft tissues occupied the lacrimal sac area and peri-lacrimal sac area, and no obvious bone destruction was found (Fig. 6F). Both patients underwent lacrimal sac and nasolacrimal duct resection.

**Discussion**

Lacrimal sac tumors are uncommon, but more than 55% (55-100%) of tumors are malignant. Thus they tend to be locally aggressive with a high recurrence rate, potentially life-threatening[4-7,18]. Although lacrimal sac tumors can have serious consequences, the clinical diagnosis of lacrimal sac tumors remains unsatisfactory. In an early study, 43% of lacrimal sac tumors were found inadvertently at the time of dacryocystorhinostomy[19]. In recent years, case reports have been abundant in which lacrimal sac tumors were discovered inadvertently during surgery[8-10]. This delayed diagnosis may be related to the following two reasons. First, most sac tumors appear with signs and symptoms similar to dacryocystitis. Moreover, in some cases, a definite tumor mass may not be palpable at the early stages. Second, preoperative examinations remain insufficient due to the low incidence of lacrimal sac tumors. A web-based questionnaire study from the Surgeons of the American Society of Ophthalmic Plastic and Reconstruction reported that less than 5% of patients underwent orbital CT before lacrimal surgery[11].
CT is widely used in clinical examination of lacrimal sac SOLs, showing a lacrimal sac mass and the extent of bony erosion and/or invasion into surrounding structures. A CT-DCG of the lacrimal drainage system can show the location of the lacrimal sac and supply additional anatomical information, such as an angiographic defect that can occur due to the lacrimal sac SOL. Several studies have suggested that preoperative DCG, CT or combined CT-DCG are important and integral in patients being considered for the endoscopic DCR[20-23]. In the current study, except for a tiny polyp, both CT-DCG and CT could show characteristic imaging changes in all the soft tissue SOLs. In this study, CDU could not identify the case of inflammatory granuloma combined with concretion, while the CT-DCG suggested that the two filling defects may be independent. Although CT and CT-DCG have many advantages in detecting lacrimal sac SOLs, their resolution is relatively low. Moreover, they cannot show whether the SOLs contain blood supply. That results in shortcomings in the differential diagnosis of the disease. In addition, the current preoperative CT or CT-DCG examination rate is still low, resulting in frequently missed diagnosis of lacrimal sac tumors[8-10,19]. Nonetheless, we speculate that this may be related to the low incidence of lacrimal sac tumors, the cost of CT examination, radiation, and examination time.

In this study, we provided the first detailed description of the imaging changes of CDU in lacrimal sac SOLs. In the 21 cases included in this study, CDU detects SOLs, including a tiny lacrimal sac polyp with a diameter of about 1mm*2mm, which was not diagnosed by CT angiography. The edges, shapes, internal echo, position, and blood flow signal of SOL could be presented in the CDU. Polyps, mucoceles, and mucoprotein concretions show characteristic changes in CDU examination. Thus, it plays an important role in the differential diagnosis of diseases. Among them, large mucoprotein concretions and mucoceles are palpable masses in the lacrimal sac area, which need to be fully differentiated from lacrimal sac tumors. In addition, large mucoprotein concretions and mucoceles can appear as soft tissue density masses on CT-DCG or CT, similar to the tumor's appearance. Additional investigations may be required to distinguish them from the lacrimal sac tumors, such as contrast-enhanced CT, magnetic resonance, or enhanced magnetic resonance. Of note, no characteristic changes were observed in the morphology of tumor, inflammation, and inflammatory granuloma combined with concretion.

Compared with CT, CDU cannot penetrate the bone. Thus CT has a better advantage in detecting the bone or surrounding structure's involvement in SOL. However, CDU has a higher resolution of soft tissue and can detect blood flow to the SOLs. In addition, CDU inspection is more convenient, less expensive, and free of radiation. Based on the current low CT or CT-DCG examination rate before DCR, we suggest that CDU can be used as a routine examination before DCR in patients without preoperative CT or CT-DCG. Moreover, CT or CT-DCG can be supplemented to provide more evidence for planning treatment strategies for any detected SOL.

In summary, CDU can detect the morphology and internal blood flow signals of lacrimal sac SOLs. Therefore, the CDU can be used as an important assessment method to discover and observe lacrimal sac SOLs. CT, or CT-DCG, is an important conventional examination method for diagnosing lacrimal sac SOLs. It has advantages in observing structural damage around the lacrimal sac mass. Therefore, CDU can be used as a routine examination to exclude lacrimal sac SOLs before DCR in the absence of preoperative CT or CT-DCG.
Summary

What was known before

- Space-occupying lesions SOLs in lacrimal sac sometimes can be found in surgery of dacryocystorhinostomy, which were often misdiagnosed in clinical practices for lack of preoperative examination.

- Computed tomography dacryocystography CT-DCG and computed tomography (CT) were considered to be effective in recognizing lacrimal sac SOLs, but these two methods lack the specific classification of SOLs due to the low resolution of soft tissue and inability to detect blood flow.

What this study adds

- Color Doppler ultrasound (CDU) can effectively identify SOLs in lacrimal sac, characteristic changes can be find in polyps, mucoceles, and mucopeptide concretions by CDU, which is helpful to distinguish these diseases from lacrimal sac tumors.

- CDU may be used as a routine examination to exclude lacrimal sac SOLs before DCR in the absence of preoperative CT or CT-DCG.

Declarations

FINANCIAL SUPPORT

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CONFLICT OF INTEREST

No conflicting relationship exists for any author.

AUTHOR CONTRIBUTIONS

All mentioned authors contributed to the study conception and design. Data collection, and analysis were performed by BY, YY and JLD. The first draft of the manuscript was written by ZBQ, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

References


**Figures**

**Figure 1**

Imaging features of polyps in CDU and CT-DCG. A. a round-like with uniform internal echo and a clear margin was detected during the conventional ultrasound. The yellow arrow shows the narrow connection between the base of mass and the wall of the lacrimal sac; B. CDU showed lined blood flow signal inside of mass(yellow arrow); C. CT-DCG showed a round filling defect of soft tissue density connected to the lacrimal sac wall (yellow arrow); D. Smooth-surfaced spherical-like soft tissue found during surgery (yellow arrow).
Figure 2

Imaging features of mucoceles in CDU and CT-DCG. A. B. an oval shape and a "hill"-like shape with moderate-intensity flocculation echoes, which gradually increased from top to bottom. The echoes of the posterior wall of the lacrimal sac were significantly enhanced as detected in conventional ultrasound. The red arrow showed top echoes, the yellow arrow showed bottom echoes; C. CDU showed no blood flow signal inside of mass; D. CT showed soft tissue mass in the lacrimal sac without obvious bone destruction.
Figure 3

Imaging features of mucoprotein concretions in CDU and CT-DCG. A. an oval-like shape with a clear, not smooth edge and uneven internal echoes inside was detected during the conventional ultrasound. In addition, the yellow arrow showed echo attenuation; B. CDU showed no blood flow signal inside of mass; C. showed soft tissue mass in the lacrimal sac without obvious bone destruction (yellow arrow); D. A large mucoprotein concretions were found during surgery (yellow arrow).
Figure 4

Imaging features of inflammatory granuloma in CDU and CT. A. An irregular shape mass with a clear, not smooth edge and uneven internal echoes inside, with the base adhering to the sac wall. The CDU showed abundant blood flow signals; B. CT showed soft tissue mass in the lacrimal sac without obvious bone destruction (yellow arrow), and the high-density zone is hydroxyapatite orbital implant (red arrow).
Figure 5

Imaging features of inflammatory granuloma complicated with concretion in CDU and CT-DCG. A. An irregular shape mass with unclear edge and uneven internal echoes inside, with the bottom adhering to the lacrimal sac; B. CDU showed speckled blood flow near the sac wall; C. CT-DCG showed extensive irregular soft-tissue filling defect with uneven margin attached to the lacrimal sac wall (yellow arrow); D. CT-DCG showed a filling defect of soft tissue not adjacent to the lacrimal sac wall (yellow arrow); E. Granulomatous hyperplasia can be observed on the wall of the lacrimal sac during surgery (yellow arrow). The blue rectangular area represents the intraoperatively resected mucosa for pathological examination.
Figure 6

Imaging features of lacrimal sac tumor in CDU and CT-DCG. A. A moderate echogenic solid mass filled the entire lacrimal sac, with a well-defined border and inhomogeneous internal echoes; B. A moderate echogenic solid mass filling the entire lacrimal sac, with unclear border and inhomogeneous internal echoes; C. CDU showed scattered punctate blood flow signals in melanocytic carcinomas; D. CDU showed more abundant blood flow signals in squamous cell carcinomas; E. CT showed soft tissue mass in the lacrimal sac with slight bone erosion (yellow arrow).