Computed tomographic dacryocystography in children undergoing balloon dacryoplasty

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PURPOSE To ascertain whether the volume and circumference of the lacrimal sac and nasolacrimal duct as measured by contrast-enhanced computed tomographic dacryocystography (CT-DCG) before and after balloon dacryoplasty could be used to predict clinical success in children with congenital nasolacrimal obstruction.

METHODS Nasolacrimal ducts of children aged 2 to 6 years with clinical signs of congenital nasolacrimal duct obstruction undergoing balloon dilation were imaged with contrast-enhanced CT-DCG before and 5 minutes after the procedure. The circumference of the most dilated portion of the lacrimal sac was measured on the axial plane. The volume of contrast within the nasolacrimal duct and sac was also measured before and after the procedure. Clinical success was defined as the disappearance of signs of epiphora.

RESULTS A total of 18 nasolacrimal ducts of 13 children were included. The average circumference of the most dilated portion of the lacrimal sac was 1.30 ± 0.45 cm (range, 0.64–2.50 cm) before the procedure. The average contrast volume was 0.12 ± 0.08 cm^3 (range, 0.01-0.38 cm^3) before and 0.07 ± 0.06 cm^3 (range, 0.01–0.20 cm^3) after ($P = 0.01$). Data were analyzed using multivariate logistic regression with a backward variable input model; a decrease in contrast volume before and after dilation ($P = 0.04$) was associated with clinical success, whereas the larger size of the most dilated portion of the lacrimal sac ($P = 0.01$) was associated with clinical failure.

CONCLUSIONS Contrast-enhanced CT-DCG provides useful information about nasolacrimal anatomy in children with congenital nasolacrimal duct obstruction. The decrease in contrast volume before and after balloon dilation was predictive of success; A larger size of the most dilated portion of the lacrimal sac was associated with clinical failure. (J AAPOS 2012;16:464-467)

Congenital nasolacrimal duct obstruction (CNLDO) is the most common lacrimal system abnormality in children, with an incidence ranging between 1.8% and 20% during the first year of life.[1-4] Balloon catheterization[5-7] has been used successfully in children >2 years of age with CNLDO as well as in those who were not successfully treated with probing.[8-10] Little is known about the radiologic details of the nasolacrimal system in children, who must be imaged under general anesthesia. The lacrimal systems of children with dacryocystocele can, however, be successfully imaged through CT dacryocystographic observations.[11] Freitag and colleagues[12] developed a technique wherein a contrast medium is injected into the nasolacrimal ducts; digital subtraction dacryocystography (DCG) and CT scanning with multidetectors (CT-MD) is performed, and images are reconstructed in three dimensions (3D), which permits both evaluation of the contrast column as a whole in the bone structures and also 3D image rotation, facilitating the identification of areas of stenosis or expansion effect that may not be apparent in the oblique or anteroposterior incidences of conventional DCG.[13] The purpose of the current study was to evaluate the volume and circumference of the lacrimal sac and the nasolacrimal duct in children with CNLDO using CT-DCG-MD before and after balloon dilation in terms of clinical success.

Subjects and Methods

This study was a prospective, interventional, case series conducted at the nasolacrimal duct sector of the Reference Center in Ophthalmology of the Federal University of Goiás (CEROF/UFG) and the UFG Radiology Service. Children cared for at the CEROF/UFG clinic who were diagnosed with CNLDO from January to October 2008 were eligible for inclusion. The protocol was initially approved by the UFG Ethics Committee on Medical, Human, and Animal Research and the National Council of Ethics and Research. All parents or guardians of the patients included in

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the study read and signed the terms of informed consent. Cases were collected sequentially from a list of patients with clinical diagnosis of CNLDO, according to the chronologic order of attendance at the CEROF/UFG Nasolacrimal Duct Clinic.

Inclusion criteria were as follows: age between 2 and 6 years; congenital nasolacrimal duct obstruction diagnosis made in the presence of clinical signs of CNLDO (teary eye with mucopurulent discharge or crust in the eyelashes) and confirmed by the fluorescein dye disappearance test; a minimum postoperative follow-up of 1 year.[14] Patients with any of the following were excluded: ectropion of the lacrimal punctum or the lower eyelid; congenital absence of the punctum; paralytic lagophthalmos; alterations in the eyelid structure that could cause tearing (trichiasis, entropion); ocular inflammations or emergencies, such as orbital cellulitis, conjunctivitis, and infectious keratitis, sty, or acute dacryocystitis; history of prior surgical procedures on the nasolacrimal ducts, such as conventional probing, intubation with silicone thread, or dacryocystorhinostomy; or history of facial trauma or nose fracture.

Balloon dacryoplasty was performed under general anesthesia in accordance with the standard protocol,[5-7] using the LacriCath system (Atrion, Birmingham, AL) according to manufacturer's recommendations. The balloon was inserted into the distal nasolacrimal duct through the valve of Hasner and inflated to 8 atm for 90 seconds, deflated, and reinflated for 60 seconds. The balloon catheter was then moved 10 mm proximally and reinflated in a similar fashion. The silicone tube was not used after the dilation. Nasolacrimal patency at the end of the procedure was ascertained by CT-DCG-MD verification of contrast inside the nasal cavity with the aspiration cannula. Operation and image acquisitions took place in the same room. The total mean operation time, including imaging and general anesthesia, was 1 hour. Antibiotic and corticosteroid eye drops every 3 hours for 15 days were prescribed. Patients were evaluated by the same author (RMLSC) at the CEROF/UFG Nasolacrimal Duct Clinic at 3 weeks, at 6 months, and 1 year after balloon dilation; success was defined as the disappearance of signs and symptoms of epiphora, confirmed by an external ocular examination using the dye disappearance test.[14]

CT-DCG-MD was performed prior to and 5 minutes after the surgical procedure. Images were acquired after injection of a water-soluble iodinated contrast medium (lohexl, 300 mg/mL) through the dilated lower lacrimal punctum using a six-channel multidetector CT scanner (Somatom Emotion; Siemens Medical Solutions, Inc., Erlangen, Germany), with a minimal dosage of radiation (mean dosage, [CTDIvol], 11.2 mGy) less than the suggested dosage for routine CT scans of cranial bones in children (12.9 mGy). 3D reconstructions were made in the axial, coronal, and oblique sagittal planes, with continuous 0.6 mm acquisitions (Viewer Sinet Siemens), including reconstructions with bone subtraction to improve visualization of the contrast column inside the nasolacrimal ducts. Images were rotated at 25-degree intervals, left to right, and analyzed by the head researcher (RML) and the radiology technician.

Cross-sectional areas of the lacrimal sac and duct were determined for all axial slices from the upper to the lower part of the contrast column using CT workstations. All of the areas were defined using a cursor to encircle the entire contrast column in the lacrimal system.

The circumference of the most dilated portion of the lacrimal sac was measured in the axial plane. All of the axial slices were analyzed and the circumference was measured in the slice that presented a larger visible area of contrast in the lacrimal sac (Figure 1). This measurement was made only before balloon dilation because it depends on the presence of contrast medium inside the lacrimal duct and sac. The volume of contrast within the nasolacrimal duct and sac was measured before and 5 minutes after the procedure using Viewer Sinet Siemens (Figure 1).

Statistical Analysis

The Statistical Package for the Social Sciences 15.0 (SPSS, Inc., Chicago, IL) was used for statistical analysis. The Kolmogorov-Smirnov test was used to determine the normality of the data. Multivariate logistic regression analysis with a backward variable input model was used to assess the ratio of procedure success (dependent variable) with variables that could interfere in dilation results with the balloon catheter. The following independent variables were included: difference in volume before and after, difference in volume in percentage, age in months, most dilated portion of the lacrimal sac, and positive sac expression (purulent discharge). The Pearson correlation was used to evaluate the linear relation between variables of interest for comparison. $P < 0.05$ was considered statistically significant.

Results

A total of 18 nasolacrimal ducts of 13 children (average age, 38.13 ± 11.26 months; range, 26-64 months) were included in this study. Of the 13 children, 5 had bilateral CNLDO. The average circumference of the most dilated portion of the lacrimal sac before the procedure was 1.30 ± 0.45 cm (range, 0.64-2.50 cm). The average contrast volume was 0.12 ± 0.08 cm^3 (range, 0.01–0.38 cm^3) before and 0.07 ± 0.06 cm^3 (range, 0.01–0.20 cm^3) after the procedure ($P = 0.01$; Figure 2 and e-Supplement 1, available at jaapos.org).

Among the 18 lacrimal systems treated, 9 (50%) had purulent discharge on lacrimal sac expression before the procedure. All of the cases presented free flow of contrast inside the nasal cavity after the procedure. There was only one unsuccessful case, which presented signs and symptoms of epiphora confirmed by the dye disappearance test at 3 week postoperative follow-up. This case maintained the signs of epiphora at 1 year follow-up. All other 17 cases had success observed at all three follow-up examinations.

Using multivariate logistic regression analysis with a backward variable input model, the difference in contrast volume before and after dilation ($P = 0.04$) and the size of the most dilated portion of the lacrimal sac ($P = 0.01$) were found to be correlated with success. Lacrimal sac expression ($P = 0.9$), age in months ($P = 0.8$), and difference in contrast volume in percentage ($P = 0.7$) were not significantly correlated with success. There was no positive correlation between age and the most dilated portion of the lacrimal sac ($r = 0.278$, $P = 0.2$).

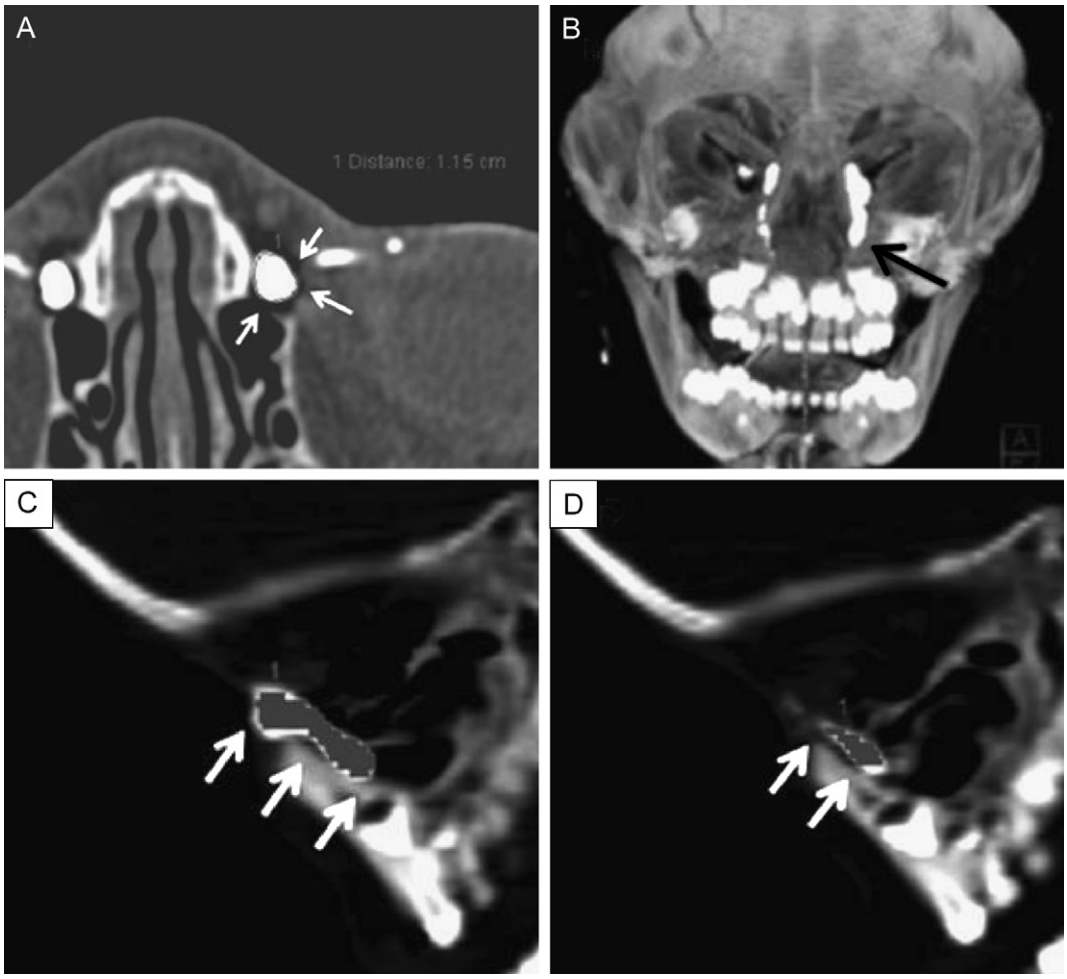

FIG 1. A, Axial CT-MD slice showing the circumference of the contrast column (arrows) in the nasolacrimal duct. B, CT-DCG-MD with 3D reconstruction showing complete obstruction (arrows) of the left lacrimal system from the front view. C, 3D representation of the measured volume of the contrast column (arrows) before the procedure. D, 3D of the measured volume of the contrast column representation (arrows) after the procedure (same patient as C).

Discussion

Among the 18 lacrimal systems treated, 17 had complete resolution of epiphora, indicting that the balloon dacryoplasty procedure was successful in his group of children. Of the 18 evaluated nasolacrimal systems, the average circumference of the most dilated portion of the lacrimal sac was 1.30 ± 0.45 cm. This value could be explained by the relatively advanced age of the children included in the study (average, 38.13 ± 11.26 months), suggesting that untreated CNLDO may lead to the dilation of the nasolacrimal duct and sac over time. It should be noted that injection of fluid may produce distension in an obstructed sac, and that the volume of material could influence this distension; however, there was no positive correlation between age and the most dilated portion of the lacrimal sac ($r = 0.278$, $P = 0.2$).

Moscato and colleagues[15] evaluated nasolacrimal duct volume in children up to 34 months of age and without any history of CNLDO using CT-MD, but they did not use any contrast agent. On average, nasolacrimal duct volume in their study ranged between 0.041 and 0.286 cm^3. In this study, contrast volume in the nasolacrimal duct before the procedure averaged 0.12 ± 0.08 cm^3. Our higher values can be partially explained by the fact that all the patients included had CNLDO. In contrast to the current study, Moscato and colleagues[15] measured the volume of bony nasolacrimal duct (the part surrounded by bones) but not the membranous part (near the Hasner valve); this confounding variable may also partly explain the difference between our results.

The difference between contrast volume before and after the procedure was statistically significant ($P = 0.01$), suggesting there was a good flow of contrast to the interior of the nasal cavity in most cases. It should be noted, however, that the decrease in volume after the balloon procedure reflects release of the "bottleneck" inside the nasolacrimal duct. Of the 18 nasolacrimal ducts, 5 had no difference in volume before and after the procedure. A possible explanation for this is the presence of an immediate postoperative edema at the Hasner valve level, preventing the free flow of the contrast medium. Alternative

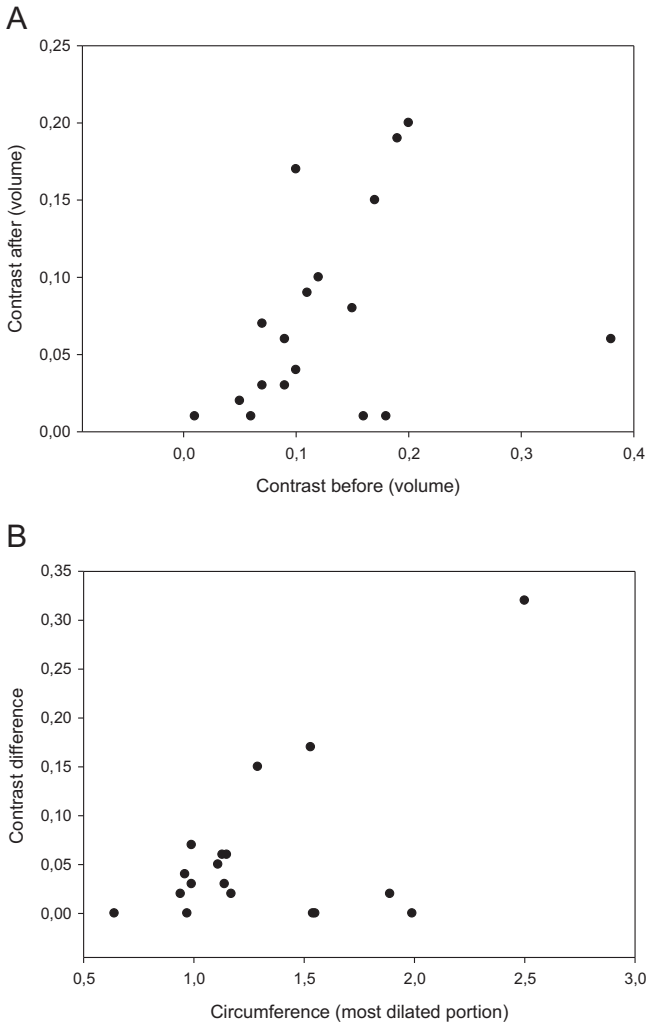

FIG 2. A, Scatterplot of contrast volume (cm^3) before and after balloon dilation. B, Scatterplot of contrast difference (cm^3) before and after balloon dilation and the circumference of the most dilated portion of the lacrimal sac.

explanations include the presence of a flaccid sac, which would not shrink immediately after pressure was relieved, or a trapdoor valve effect. Although a difference in the contrast volume is significant, the same calculation as a percentage is not, probably because the difference in percentage does not reflect the amount of the volume inside the lacrimal sac before the procedure.

Only 1 of the 18 cases was unsuccessful. This case was among the five that did not present any difference between volume before and after the procedure. In this case the value found for the measured circumference of the most dilated portion of the lacrimal sac before the procedure was 1.99 cm (e-Supplement 1), raising the possibility that low values in the difference between volume before and after, denoting difficulty for the contrast to flow to the nasal cavity, associated with a dilated lacrimal sac, may be predictive of procedure failure. To corroborate this hypothesis, multivariate logistic regression analysis was used to show that only the difference in contrast volume before and after ($P = 0.04$) and the most dilated portion of the lacrimal sac ($P = 0.01$) were determining factors for procedure success. This unsuccessful case underwent dacryocystorhinostomy.

Limitations of this study include its unmasked nature, the small sample size, the inclusion criteria (patients aged 2-6 years of age only), and the lack of a control group. However, no positive and considerable bias is believed to have occurred. It is unlikely that this procedure (CT-DCG-MD) will become a standard protocol for CNLDO, but perhaps it could be useful in complicated cases of CNLDO, such as cases of lacrimal outflow dysgenesis or reoperations.

Literature Search

MEDLINE and PubMed were searched without date or language restriction after bibliographical research for the following terms: *obstruction of nasolacrimal ducts* AND *congenital*, *balloon dilation* AND *radiology*.

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