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Factors Predictive of Subretinal Fluid Resolution in Coats Disease: Analysis of 177 Eyes in 177 Patients at a Single Center

Chloe T.L. Khoo, MD, Lauren A. Dalvin, MD*†, Li-Anne S. Lim, MD*, Mehdi Mazloumi, MD, MPH*, Hatice T. Atalay, MD*, Sanika Udyaver, BS*, Jerry A. Shields, MD*, and Carol L. Shields, MD**

Purpose: The aim of this study was to investigate factors predictive of subretinal fluid (SRF) resolution in Coats disease.

Design: Retrospective cohort study.

Methods: Institutional review board-approved review of patients diagnosed with Coats disease demonstrating SRF (stage 3–5) at a single center from November 1973 to July 2018 with comparison of eyes that had resolution of SRF to those in which SRF persisted.

Results: There were 177 cases (154 males, 87%) of Coats disease diagnosed at a mean age of 8 years. After a mean follow-up of 62 months, SRF resolved in 110 (62%) and persisted in 67 (38%) eyes. Comparison (resolved SRF vs persistent SRF) revealed classification as stage 3A [63 (57%) vs 20 (29%)], stage 3B [47 (43%) vs 40 (60%)], or stage 4 [0 (0%) vs 7 (11%)] ($P < 0.001$). Eyes with resolved SRF presented with fewer clock hours of telangiectasia (mean: 5 vs 7 clock hours, $P < 0.001$), light bulb aneurysms (mean: 5 vs 7 clock hours, $P < 0.001$), exudation (mean: 7 vs 10 clock hours, $P < 0.001$), and extent of SRF (mean: 7 vs 10 clock hours, $P < 0.001$). Factors predictive of SRF resolution included absence of iris neovascularization on fluorescein angiography [odds ratio 0.05 (95% confidence interval 0.01–0.60), $P = 0.02$], and less elevated SRF by ultrasonography [odds ratio 0.84 (95% confidence interval 0.76–0.95), $P = 0.004$). For every 1-mm decrease in SRF, likelihood of SRF resolution increased by 16%.

Conclusions: Resolution of SRF was achieved in the majority of eyes (62%) with stage 3 to 5 Coats disease. Predictors of SRF resolution included lack of neovascularization on fluorescein angiography and less elevation of SRF by ultrasonography.

Key Words: Coats disease, exudation, retinal detachment, subretinal fluid, telangiectasia

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In 1908, Coats[1] first described 6 unilateral cases of retinal vascular abnormalities and retinal exudation, subsequently coining the term "Coats disease." Later, in 1912, Leber[2] described a condition characterized by multiple retinal aneurysms with little or no exudation, subsequently coining the term "Lebers miliary aneurysms." These 2 conditions were initially considered distinct; however, in 1956, Reese[3] proposed that both conditions represented a spectrum of a singular entity, with progression from retinal telangiectasia to exudative retinopathy.

In 2001, Shields et al[4] reviewed a series of 150 patients with Coats disease and found the most common anterior segment findings included neovascularization of iris (NVI) (8%), whereas posterior segment findings included telangiectasia (100%), intraretinal exudation (99%), and exudative retinal detachment (RD) (81%). Egerer et al[5] studied 31 cases of Coats disease and found that disease severity corresponded to the degree of retinal exudation, hemorrhage, and small vessel damage.

Shields et al[6] previously classified Coats disease into 5 stages: stage 1 (retinal telangiectasia); stage 2 (telangiectasia and exudation) [stage 2A (extrafoveal exudation) and stage 2B (foveal exudation)]; stage 3 (exudative RD) [stage 3A1 (subtotal RD sparing fovea), stage 3A2 (subtotal RD involving fovea), and stage 3B (total RD)]; stage 4 (total RD with secondary glaucoma); and stage 5 (advanced end-stage disease with chronic inflammation, posterior synechia, and cataract). Stage 1 disease was often asymptomatic and was observed or prophylactically treated with laser photocoagulation, whereas stages with increasing amounts of retinal exudation or subretinal fluid (SRF) were associated with decreased visual acuity, requiring treatment with modalities such as laser photocoagulation, cryotherapy, or a combination of RD repair with SRF drainage and laser photocoagulation or cryotherapy.[6] According to Shields et al,[6] poor visual outcome (20/200 or worse) was found in 0% of eyes with stage 1, 53% with stage 2, 74% with stage 3, and 100% with stage 4 and 5 Coats disease.

Although studies have shown that SRF is associated with disease severity and visual acuity outcome, there is little information in the literature regarding SRF resolution in Coats disease. Most studies have focused on Coats disease as a whole, or subdivided Coats disease based on classification.[1–6] Although experience dictates that shallow SRF tends to resolve whereas more advanced SRF shows slower resolution, factors that predict resolution have not been thoroughly investigated. Herein, we explore factors predictive of SRF resolution in eyes with Coats disease based on presenting clinical features, classification, and treatment strategy in 177 consecutive eyes with Coats disease demonstrating SRF.

METHODS

The medical records for all patients presenting with Coats disease diagnosed between November 1, 1973 and July 31, 2018 at the Ocular Oncology Service of Wills Eye Hospital, Thomas

From the *Ocular Oncology Service, Wills Eye Hospital, Thomas Jefferson University, 840 Walnut Street, 14th Floor, Philadelphia, PA, 19107; and †Dr. Dalvin has an appointment with the Department of Ophthalmology, Mayo Clinic, Rochester, MN.

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Correspondence: Carol L. Shields, Ocular Oncology Service, 840 Walnut Street, Suite 1440, Philadelphia, PA 19107. E-mail: carolshields@gmail.com.

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Jefferson University, Philadelphia, PA, were retrospectively reviewed. Patients with SRF, that is, those with stage 3 to 4 Coats disease, were included in this study. Patients with stage 1 or 2 Coats disease with no evidence of SRF, or those with inadequate follow-up or incomplete medical records, were excluded. Patients were separated into 2 groups based on response to treatment including those with SRF resolution versus those with SRF persistence. Institutional Review Board approval was obtained from Wills Eye Hospital and informed consent was obtained from all patients.

Patient data reviewed from medical records included patient demographics (age at presentation, sex, race, and disease laterality) presenting clinical features (presenting symptoms, intraocular pressures, best-corrected visual acuity, anterior and posterior segment findings, disease staging, extent of telangiectasia, light bulb aneurysms, exudation, and SRF). Imaging features included fluorescein angiography (FA) (retinal nonperfusion and most affected quadrants, telangiectasia, light bulb aneurysms, NVI, neovascularization of disc, and neovascularization elsewhere) and ultrasonography (US) (type of RD and SRF elevation in millimeters). Treatment modalities were reviewed [observation, argon laser photocoagulation, cryotherapy, photodynamic therapy, transpupillary thermotherapy, sub-Tenon's corticosteroid injection, intravitreal corticosteroid injection, antivascular endothelial growth factor (VEGF) injection, or primary enucleation]. Data were tabulated in Microsoft Excel 2016 and analyzed using SPSS software (version 18.0 for Windows; SPSS Inc., Chicago, IL). Comparative statistical analysis was performed between eyes with resolved SRF and eyes with persistent SRF using Student *t* test for continuous variables and chi-square or Fisher exact test for categorical variables. Binomial logistic regression was performed to adjust for potential confounders and was used to determine factors predictive of SRF resolution. Statistical significance was defined as $P < 0.05$. Odds ratio (OR) was reported as OR (95% confidence interval).

RESULTS

There were 351 eyes from 351 patients diagnosed with Coats disease on the Ocular Oncology Service at Wills Eye Hospital during the study period. Of the 351 eyes, 177 eyes (50%) from 177 patients were diagnosed with stage 3 to 4 Coats disease. Of those, 110 eyes (62%) from 110 patients showed resolution of SRF after a mean follow-up of 64 months (Fig. 1), whereas 67 eyes (38%) from 67 patients had persistent SRF after a mean follow-up of 59 months ($P = 0.65$) (Fig. 2).

Baseline demographic data are listed in Table 1. Comparison of the 2 groups (resolved SRF vs persistent SRF) showed no significant difference in mean age (9 vs 6 years, $P = 0.15$), sex [male: 97 (88%) vs 57 (85%), $P = 0.55$], or race [Caucasian: 79 (72%) vs 45 (67%), $P = 0.79$].

Clinical features are listed in Table 2. Common presenting signs and symptoms included xanthocoria [17 (15%) vs 21 (32%)], strabismus [27 (25%) vs 21 (32%)], and vision loss [41 (37%) vs 15 (23%)] ($P = 0.03$). Among patients who were able to verbally report vision, baseline visual acuity was more frequently 20/200 or better in patients with resolved SRF [38 (35%) vs 8 (12%), $P = 0.003$]. Patients were classified into stage 3A1 [20 (18%) vs 11 (16%)], stage 3A2 [43 (39%) vs 9 (13%)], stage 3B [47 (43%) vs 40 (60%)], and stage 4 [0 (0%) vs 7 (11%)] ($P < 0.001$). There were no stage 5 eyes seen in our practice during this time period. Eyes with resolved SRF presented with less NVI [2 (2%) vs 8 (12%), $P = 0.01$], fewer clock hours of telangiectasia (mean: 5 vs 7 clock hours, $P < 0.001$), light bulb aneurysms (mean: 5 vs 7 clock hours, $P < 0.001$), exudation (mean: 7 vs 10 clock hours, $P < 0.001$), and SRF extent (mean: 7 vs 10 clock hours, $P < 0.001$).

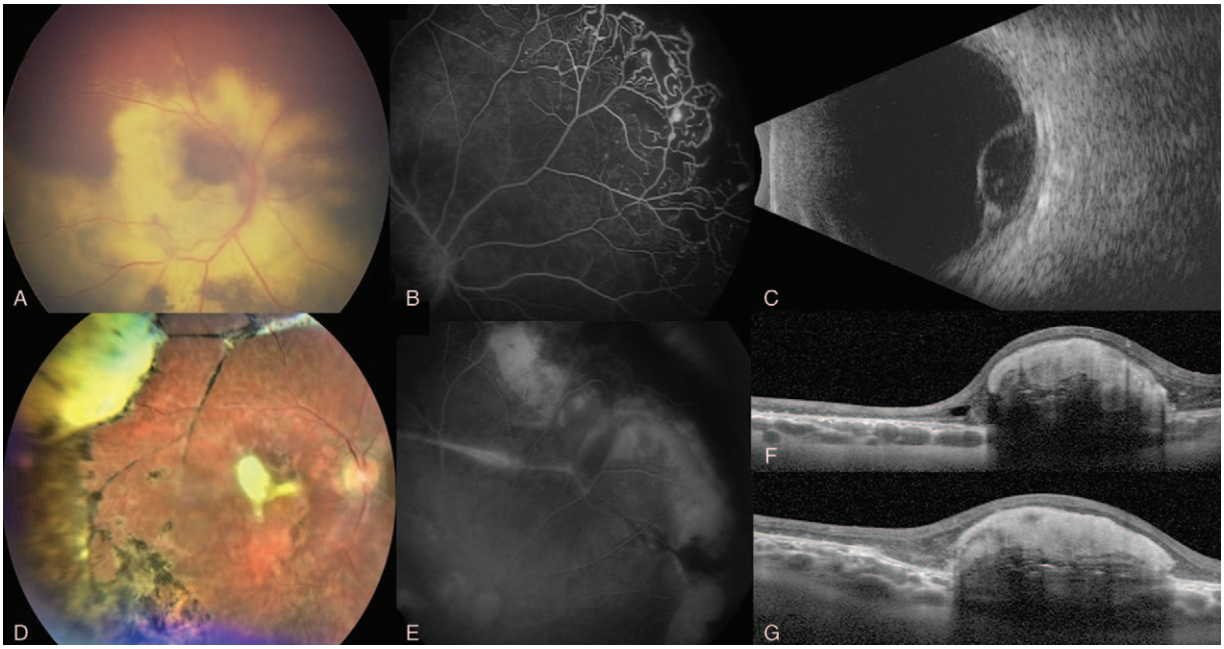

FIGURE 1. Coats disease with resolution of subretinal fluid (SRF). A 4-year-old white boy presented with xanthocoria and (A) exudation involving the macula and inferior quadrant of the retina consistent with stage 3A2 Coats disease. Fluorescein angiography (B) revealed telangiectasia and light bulb aneurysms for 360 degrees in the periphery. Ultrasonography (C) confirmed the findings of exudation and macular SRF. Treatment with a total of 3 sessions of argon laser photocoagulation and 2 sessions of cryotherapy resulted in SRF resolution. At 98-month follow-up, there was flat retina with subfoveal gliosis (D), appearing hypofluorescent on fluorescein angiography (E), and confirmed on both horizontal (F) and vertical cut optical coherence tomography (G).

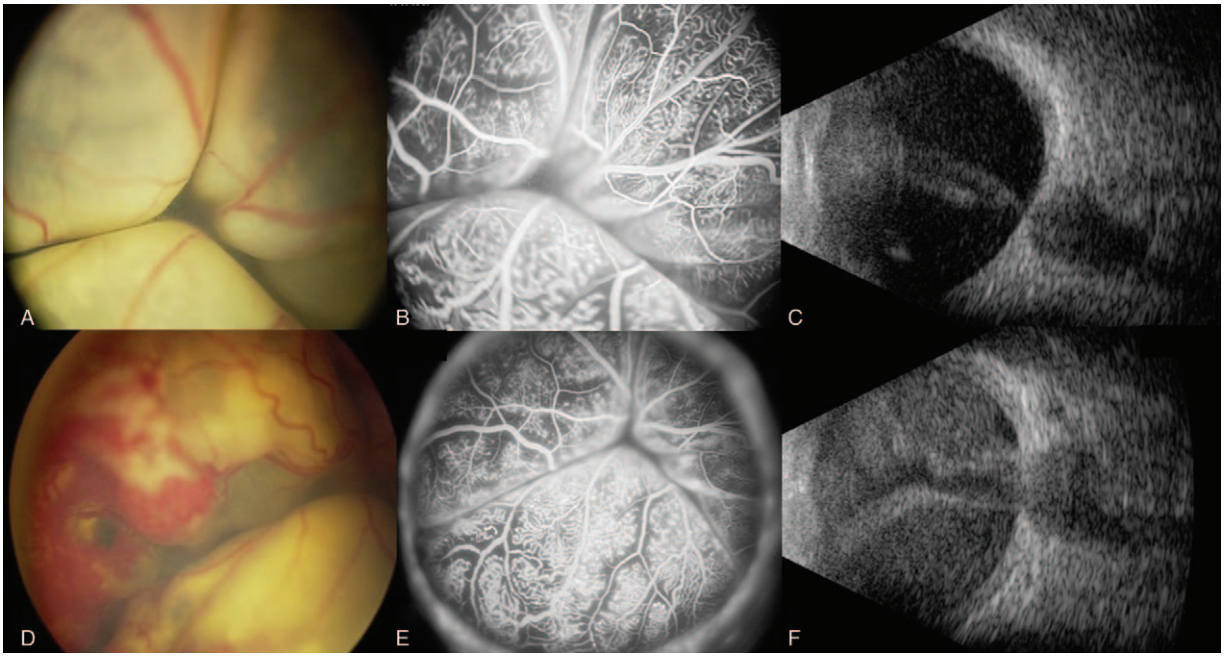

FIGURE 2. Coats disease with persistent subretinal fluid (SRF). A 15-month-old African American boy presented with xanthocoria and (A) total exudative retinal detachment consistent with stage 3B Coats disease. Fluorescein angiography (B) revealed telangiectasia and light bulb aneurysms involving all 12 clock hours. Ultrasonography (C) confirmed the findings of total exudative retinal detachment. Treatment with sub-Tenon's triamcinolone failed to improve SRF. At 3-month follow-up, there was persistent total exudative retinal detachment (D), seen on fluorescein angiography (E) and ultrasonography (F).

Imaging features are listed in Table 3. On FA, comparison of the 2 groups (resolved SRF vs persistent SRF) revealed no significant difference in retinal nonperfusion presence [79 (90%) vs 31 (78%), $P = 0.06$] or mean number of clock hours (6 vs 6 clock hours, $P = 0.57$). Eyes with resolved SRF had fewer clock hours of telangiectasia (mean: 6 vs 7 clock hours, $P = 0.01$), light bulb aneurysms (mean: 5 vs 7 clock hours, $P = 0.004$), and NVI [1 (1%) vs 8 (20%), $P < 0.001$]. On US, eyes with resolved SRF presented with fewer open funnel [19 (24%) vs 21 (43%), $P = 0.03$], or closed funnel RD [1 (1%) vs 11 (22%), $P < 0.001$], and less SRF elevation by US (mean: 2.3 vs 8.5 mm, $P < 0.001$).

Treatment modalities are listed in Table 4. Fewer eyes with resolved SRF were observed [2 (2%) vs 10 (15%), $P = 0.002$], whereas more eyes with resolved SRF were treated with argon laser photocoagulation [65 (61%) vs 18 (34%), $P = 0.003$] and cryotherapy [97 (91%) vs 40 (75%), $P = 0.02$] but fewer intravitreal corticosteroid injections [2 (2%) vs 6 (11%), $P = 0.03$].

TABLE 1. Patient Demographics

Patient Demographics	Resolved Subretinal Fluid, n = 110 Eyes in 110 Patients (%)	Persistent Subretinal Fluid, n = 67 Eyes in 67 Patients (%)	*P* Value	Total, N = 177 Eyes in 177 Patients (%)
Age at presentation, y Mean (median, range)	9 (5, 0–60)	6 (3, 0–38)	0.15	8 (4, 0–60)
Sex				
Male	97 (88)	57 (85)	0.55	154 (87)
Female	13 (12)	10 (15)		23 (13)
Race				
Caucasian	79 (72)	45 (67)	0.79	124 (70)
African American	19 (17)	13 (19)		32 (18)
Asian	3 (3)	1 (1)		4 (2)
Hispanic	7 (6)	6 (10)		13 (7)
Middle Eastern	1 (1)	0 (0)		1 (1)
Indian	1 (1)	2 (3)		3 (2)
Laterality				
Unilateral	110 (100)	67 (100)	NA	177 (100)
Bilateral	0 (0)	0 (0)		0 (0)
Study eye				
Right	46 (42)	39 (58)	**0.03**	85 (48)
Left	64 (58)	28 (42)		92 (52)

Bold values indicate significant *P* value. NA indicates not applicable.

TABLE 2. Clinical Features

Clinical Features	Resolved Subretinal Fluid, n = 110 Eyes in 110 Patients (%)	Persistent Subretinal Fluid, n = 67 Eyes in 67 Patients (%)	*P* Value	Total, N = 177 Eyes in 177 Patients (%)
Presenting signs and symptoms				
Xanthocoria	17 (15)	21 (32)		38 (21)
Heterochromia	0 (0)	1 (1)	**0.03**	1 (1)
Strabismus	27 (25)	21 (32)		48 (27)
Nystagmus	1 (1)	1 (1)		2 (1)
Vision loss	41 (37)	15 (23)		56 (32)
Floaters	2 (2)	1 (1)		3 (2)
Pain	0 (0)	1 (1)		1 (1)
Redness	1 (1)	0 (0)		1 (1)
Asymptomatic	21 (19)	6 (9)		27 (14)
Intraocular pressure, mean (median, range), mm Hg	15 (15, 6–25)	17 (15, 6–60)	0.10	16 (15, 6–60)
Visual acuity				
Verbal visual acuity				
>20/40	14 (13)	2 (3)	**0.003**	16 (9)
20/40–20/200	24 (22)	6 (9)		30 (17)
<20/200	36 (33)	33 (49)		69 (39)
Nonverbal visual acuity				
Fix and follow	7 (6)	3 (4)		10 (6)
Poor fix and follow	10 (9)	3 (4)	0.09	13 (7)
No fix and follow	16 (15)	20 (31)		36 (20)
Uncooperative	3 (2)	0 (0)		3 (2)
Anterior segment findings				
Xanthocoria	47 (43)	36 (54)	0.20	83 (47)
Iris neovascularization	2 (2)	8 (12)	**0.01**	10 (6)
Corneal edema	0 (0)	1 (1)	0.20	1 (1)
Phthisis	0 (0)	0 (0)	NA	0 (0)
Coats disease stage				
1	0 (0)	0 (0)		0 (0)
2A	0 (0)	0 (0)		0 (0)
2B	0 (0)	0 (0)	**<0.001**	0 (0)
3A1	20 (18)	11 (16)		31 (18)
3A2	43 (39)	9 (13)		52 (29)
3B	47 (43)	40 (60)		87 (49)
4	0 (0)	7 (11)		7 (4)
5	0 (0)	0 (0)		0 (0)
Telangiectasia, mean (median, range), clock hours	5 (5, 0–12)	7 (7, 0–12)	**<0.001**	6 (6, 0–12)
Quadrants				
0	4 (4)	1 (1)		5 (3)
1	31 (28)	11 (17)	0.06	42 (23)
2	32 (29)	16 (24)		48 (27)
3	29 (26)	18 (27)		47 (27)
4	14 (13)	20 (30)		34 (19)
No view*	0 (0)	1 (1)		1 (1)
Light bulb aneurysms, mean (median, range), clock hours	5 (4, 0–12)	7 (6, 0–12)	**<0.001**	5 (5, 0–12)
Quadrants				
0	6 (5)	3 (4)		9 (5)
1	37 (34)	13 (19)	0.06	50 (28)
2	39 (35)	20 (31)		59 (33)
3	17 (15)	13 (19)		30 (17)
4	11 (11)	17 (26)		28 (16)
No view*	0 (0)	1 (1)		1 (1)
Exudation, mean (median, range), clock hours	7 (6, 0–12)	10 (12, 1–12)	**<0.001**	8 (8, 0–12)
Quadrants				
0	1 (1)	0 (0)		1 (1)
1	13 (12)	5 (7)	**0.002**	18 (10)
2	41 (37)	10 (15)		51 (29)
3	19 (17)	9 (13)		28 (15)
4	36 (33)	42 (63)		78 (44)
No view*	0 (0)	1 (2)		1 (1)
Subretinal fluid, mean (median, range), clock hours	7 (6, 0–12)	10 (12, 1–12)	**<0.001**	8 (9, 0–12)

TABLE 2 (*Continued*)

Clinical Features	Resolved Subretinal Fluid, n = 110 Eyes in 110 Patients (%)	Persistent Subretinal Fluid, n = 67 Eyes in 67 Patients (%)	*P* Value	Total, N = 177 Eyes in 177 Patients (%)
Quadrants				
0	3 (3)	0 (0)		3 (2)
1	23 (21)	5 (7)	**<0.001**	28 (16)
2	29 (26)	7 (10)		36 (20)
3	15 (14)	6 (9)		21 (12)
4	40 (36)	49 (74)		89 (50)
Posterior segment findings				
Neovascularization of the disc	0 (0)	0 (0)	NA	0 (0)
Neovascularization of the retina	2 (2)	1 (1)	0.66	3 (2)
No view of the fundus*	0 (0)	1 (1)	0.81	1 (1)

Bold values indicate significant *P* values. NA indicates not applicable.

*No view secondary to media opacity (cataract, total exudative retinal detachment).

There was no difference in those treated with photodynamic therapy, sub-Tenon's corticosteroid therapy, or intravitreal anti-VEGF therapy.

Binomial logistic regression was performed to adjust for potential confounders, with results listed in Table 5. Factors predictive of SRF resolution included absence of NVI on FA [OR 0.05 (0.01–0.60), $P = 0.02$] and less SRF elevation by US [OR 0.84 (0.76–0.95), $P = 0.004$]. With each 1-mm decrease in SRF, the likelihood of SRF resolution increased by 16%.

DISCUSSION

Coats disease is an idiopathic retinal vascular disease characterized by retinal telangiectasia, exudation and RD.[4,6–8] Long-standing RD in these patients can lead to profound loss of visual acuity. Levinson and Hubbard[9] reviewed the outcomes of 17 cases of Coats disease treated with 577-nm yellow laser photocoagulation of which 8 cases (47%) had RD, classified as "high" (75%) or "low" (25%). A comparison (high vs low RD) regarding visual acuity outcomes revealed 20/50 or better (17% vs 27%), 20/60 to 20/200 (17% vs. 9%), and worse than 20/200 (66% vs 64%) indicating reduced visual prognosis for eyes with high RD.[9] Gupta et al[10] in a review of spectral domain optical coherence tomography (SD-OCT) features of 27 cases of Coats disease found macular SRF in 10 eyes (37%), which was associated with worse baseline and final visual acuity. Previous reports from our center[4,6] on the correlation between disease staging and visual outcome found that increasing disease severity was associated with poorer visual outcome (20/200 or worse).[6] In this report, we explore the specific factors predictive of SRF resolution in eyes with Coats disease.

TABLE 3. Imaging Features

Imaging Features	Resolved Subretinal Fluid, n = 110 Eyes in 110 Patients (%)	Persistent Subretinal Fluid, n = 67 Eyes in 67 Patients (%)	*P* Value	Total, N = 177 Eyes in 177 Patients (%)
Fluorescein angiography*	n = 88 eyes	n = 40 eyes		N = 128 eyes
Retinal nonperfusion	79 (90)	31 (78)	0.06	110 (86)
Most affected quadrant				
Temporal	60 (68)	23 (58)	0.13	83 (65)
Nasal	9 (10)	1 (3)		10 (8)
Inferior	5 (6)	5 (12)		10 (8)
Superior	5 (6)	2 (5)		7 (5)
None	9 (10)	9 (22)		18 (14)
Retinal nonperfusion clock hours Mean (median, range)	6 (6, 0–12)	6 (6, 0–12)	0.57	6 (6, 0–12)
Telangiectasia clock hours Mean (median, range)	6 (6, 0–12)	7 (8, 0–12)	**0.01**	6 (6, 0–12)
Light bulb aneurysm clock hours Mean (median, range)	5 (5, 0–12)	7 (6, 0–12)	**0.004**	6 (5, 0–12)
Neovascularization of iris	1 (1)	8 (20)	**<0.001**	9 (7)
Neovascularization of disc	0 (0)	1 (3)	0.14	1 (1)
Neovascularization elsewhere	2 (2)	1 (3)	0.94	3 (2)
Ultrasonography†	n = 78 eyes	n = 49 eyes		N = 127 eyes
Open funnel retinal detachment	19 (24)	21 (43)	**0.03**	40 (31)
Closed funnel retinal detachment	1 (1)	11 (22)	**<0.001**	12 (9)
Subretinal exudate	75 (96)	48 (98)	0.57	123 (97)
Subretinal fluid elevation, mm Mean (median, range)	2.3 (0.2, 0–19)	8.5 (8, 0–18)	**<0.001**	5 (2, 0–19)

Bold values indicate significant *P* value.

*Fluorescein angiography available in 128 eyes.

†Ultrasonography available in 127 eyes.

TABLE 4. Treatment Modalities

Treatment Modalities	Resolved Subretinal Fluid, n = 110 Eyes in 110 Patients (%)	Persistent Subretinal Fluid, n = 67 Eyes in 67 Patients (%)	*P* Value	Total, N = 177 Eyes in 177 Patients (%)
Observation	2 (2)	10 (15)	**0.002**	12 (7)
Medical or laser therapy	107 (97)	53 (79)	**<0.001**	160 (90)
Total treatments				
Mean number of sessions (median, range)	4 (4, 1–13)	3 (2, 1–11)	**0.001**	4 (3, 1–13)
Argon laser photocoagulation	65 (61)	18 (34)	**0.003**	83 (47)
Mean number of sessions (median, range)	2 (1, 1–11)	2 (2, 1–3)	0.19	2 (1, 1–11)
Cryotherapy	97 (91)	40 (75)	**0.02**	137 (77)
Mean number of sessions (median, range)	2 (2, 1–9)	2 (2, 1–7)	0.22	2 (2, 1–9)
Photodynamic therapy	1 (1)	0 (0)	0.72	1 (1)
Mean number of sessions (median, range)	1 (1, 1–1)	0 (0, 0–0)	NA	1 (1, 1–1)
Transpupillary thermotherapy	0 (0)	0 (0)	NA	0 (0)
Mean number of sessions (median, range)	0 (0, 0–0)	0 (0, 0–0)	NA	0 (0, 0–0)
Sub-Tenon's corticosteroid injections	22 (21)	9 (17)	0.74	31 (18)
Mean number of injections (median, range)	1 (1, 1–3)	1 (1, 1–2)	0.48	1 (1, 1–3)
Intravitreal corticosteroid injections	2 (2)	6 (11)	**0.03**	8 (5)
Mean number of injections (median, range)	2 (2, 1–3)	1 (1, 1–2)	0.19	1 (1, 1–3)
Anti-VEGF injections	14 (13)	7 (13)	0.82	21 (12)
Mean number of injections (median, range)	2 (1, 1–7)	2 (1, 1–5)	0.85	2 (1, 1–7)
Primary enucleation	1 (1)	4 (6)	0.13	5 (3)

Bold values indicate significant *P* value. NA indicates not applicable; VEGF, vascular endothelial growth factor.

We found factors associated with resolution of SRF included earlier stage of disease and presentation with fewer clock hours of telangiectasia, fewer light bulb aneurysms, less exudation, and less elevated SRF. Factors predictive of SRF resolution included lack of NVI on FA and less elevated SRF on US. The likelihood of SRF resolution increased by 16% for every 1-mm decrease in SRF. We noticed that most of the eyes with nonresolution of SRF were salvaged and comfortable, with good cosmetic appearance.

Treatments for SRF in Coats disease include laser photocoagulation, cryotherapy, intravitreal corticosteroid injection, anti-VEGF injections, or surgical drainage of SRF.[4,6,7,11] Treatments for shallow SRF (subtotal RD in stage 3A) include laser photocoagulation or cryotherapy to target leaking telangiectasias and promote SRF resorption.[4,9,11–13]

Historically, eyes with highly elevated SRF (total RD in stage 3B or 4) have been treated with cryotherapy or surgical reattachment of the bullous RD.[4,9,11–13] Cryotherapy was preferred over laser photocoagulation in eyes with RD,[11,14,15] as highly elevated SRF was thought to respond poorly to laser photocoagulation, due to decreased absorption of laser energy by detached retina. Additionally, there was a fear of applying laser to a nonrhegmatogenous RD for risk of inducing full-thickness retinal holes, and converting the detachment to rhegmatogenous.[9] However, subsequent studies found favorable absorption of yellow laser in eyes with total exudative RD,[9] stimulating interest in laser photocoagulation as an alternate treatment to cryotherapy in some cases.[9,14,15] Levinson and Hubbard,[9] in a study of 17 eyes with Coats disease of stage 1 (6%), stage 2A (12%), stage 2B (35%), stage 3A1 (12%), stage 3A2 (6%), and stage 3B (29%), found complete disease resolution in 16 eyes (94%) after treatment with 577-nm yellow wavelength laser after a mean of 2.5 treatment sessions and mean time of 11.2 months.[9]

Other treatments for total RD have been explored. Bergstrom and Hubbard[16] used combination intravitreal triamcinolone injection and cryotherapy in 5 cases of severe exudative RD from Coats disease and found successful retinal reattachment in 2 cases

TABLE 5. Binomial Logistic Regression of Factors Predictive of Subretinal Fluid Resolution

Characteristics	Odds Ratio	95% Confidence Interval	*P* Value
Age at presentation, y	1	0.99–1.01	0.91
Xanthocoria	2.03	0.49–8.34	0.33
Exudation (quadrants)	0.11	0.01–1.19	0.07
Neovascularization of iris by fluorescein angiography	0.05	0.01–0.60	**0.02**
Retinal nonperfusion by fluorescein angiography (clock hours)	1.04	0.86–1.27	0.66
Light bulb aneurysms by fluorescein angiography (clock hours)	0.97	0.64–1.47	0.90
Telangiectasia by fluorescein angiography (clock hours)	0.94	0.64–1.34	0.76
Subretinal fluid by ultrasound, mm	0.84	0.76–0.95	**0.004**
Number of cryotherapy treatments received	0.64	0.17–2.43	0.51
Number of argon laser photocoagulation treatments received	1.10	0.29–4.13	0.89
Number of sub-Tenon's corticosteroid injections received	1.12	0.19–6.59	0.89
Number of intravitreal corticosteroid injections received	0.04	0.0–1.12	0.06
Number of anti-VEGF injections received	1.18	0.29–4.72	0.81

Bold values indicate significant *P* values. VEGF indicates vascular endothelial growth factor.

(40%), with side effects of elevated intraocular pressure (≥26 mm Hg) requiring topical medications in 4 cases (80%) and cataract in 3 cases (60%). Li et al[17] studied anti-VEGF injection in combination with laser photocoagulation and cryotherapy in stage 3A (n = 10) and stage 3B (n = 7) Coats disease and found a decrease in the postoperative RD height by OCT and color Doppler imaging ($P < 0.001$) in 16 of 17 cases (94%), but no case had complete resolution of SRF. Although we did not report a significant difference in the use of intravitreal anti-VEGF in our 2 groups (resolved SRF vs persistent SRF), other reports have shown that intravitreal anti-VEGF in advanced Coats disease improves SRF absorption and retinal reattachment, thus increasing globe survival.[18–21] However, intravitreal bevacizumab can cause vitreoretinal fibrosis and tractional RD, so caution is required.[22] Zhang et al[23] reviewed the outcomes of 28 cases of Coats disease treated with anti-VEGF and laser photocoagulation of which eyes were stage 3A (n = 21) and 3B (n = 7). After laser photocoagulation (mean 3 sessions) and anti-VEGF injections (mean 3 injections) final visual acuity was improved from logMAR 1.57 ± 0.73 (Snellen equivalent 20/740) at baseline to 1.33 ± 0.81 (Snellen equivalent 20/400) at final follow-up ($P < 0.001$), with no significant adverse effect.[23]

Regarding surgery for total RD from Coats disease, the most common surgical method is external drainage of SRF,[4,11,12] which is preferred over internal SRF drainage due to a theoretically lower risk of proliferative vitreoretinopathy.[24] In recent years, modified external SRF drainage techniques using either transscleral or transconjunctival methods have been described in case series, but further studies are needed to establish efficacy.[25,26]

Limitations of this study include the single-center retrospective design, with treatment during the course of 45 years by 2 different surgeons. As expected, treatment for Coats disease has evolved over time, so patients in this study were not managed uniformly throughout the study period. Additionally, different surgeons could have favored different treatment algorithms. We acknowledge that eyes with persistent SRF had fewer treatments which could have been a reflection of practice pattern, patient preference, chronic retinal atrophy and fibrosis, or estimated poor visual prognosis on presentation. This could have biased study results as both groups did not receive a uniform treatment regimen. Strengths of this study include manual review of detailed medical and imaging records, with a large number of patients allowing for robust statistical analysis, resulting in the discovery of new information that could be applied to improve patient care in the future.

In summary, in this large cohort study, we found that eyes with resolved SRF were associated with less NVI and fewer clock hours of telangiectasia, light bulb aneurysms, exudation, and SRF involvement. On further analysis with binomial logistic regression, only absence of NVI on FA and less SRF on US was found to be predictive of SRF resolution. Additional studies are required to better assess visual outcomes in patients with persistent SRF and determine whether patients presenting with more advanced Coats disease should be considered for early surgical drainage.

REFERENCES

1. Coats G. Forms of retinal diseases with massive exudation. *Roy Lond Ophthalmol Hosp Rep*. 1908;17:440–525.
2. Leber T. Ueber eine durch vorkommen multipler miliaraneurysmen charakterisierte form von retinaldegeneration. *Albrecht von Graefe's Arch Klin Ophthalmol*. 1912;81:1–14. German.
3. Reese AB. Telangiectasia of the retina and Coats disease. *Am J Ophthalmol*. 1956;42:1–8.
4. Shields JA, Shields CL, Honavar SG, et al. Clinical variations and complications of Coats disease in 150 cases: The 2000 Sanford Gifford Memorial Lecture. *Am J Ophthalmol*. 2001;131:561–571.
5. Egerer I, Tasman W, Tomer TT. Coats disease. *Arch Ophthalmol*. 1974;92:109–112.
6. Shields JA, Shields CL, Honavar SG, et al. Classification and management of Coats disease: The 2000 Proctor Lecture. *Am J Ophthalmol*. 2001;131:572–583.
7. Shields JA, Shields CL. Coats disease. In: Shields JA, Shields CL, editors. Atlas of Intraocular Tumors. Philadelphia: Wolters Kluwer; 2016. p. 373–379.
8. Daruich A, Matet A, Munier FL. Younger age at presentation in children with Coats disease is associated with more advanced stage and worse visual prognosis: a retrospective study. *Retina (Philadelphia Pa)*. 2018;38:2239–2246.
9. Levinson JD, Hubbard GB. 577-nm yellow laser photocoagulation for Coats disease. *Retina (Philadelphia Pa)*. 2016;36:1388–1394.
10. Gupta MP, Dow E, Jeng-miller KW, et al. Spectral domain optical coherence tomography findings in Coats disease. *Retina (Philadelphia Pa)*. 2019;39:1177–1185.
11. Shields JA, Shields CL. Review: Coats disease: The 2001 LuEsther T. Mertz lecture. *Retina (Philadelphia Pa)*. 2002;22:80–91.
12. Ridley ME, Shields JA, Brown GC, et al. Coats disease. Evaluation of management. *Ophthalmology*. 1982;89:1381–1387.
13. Silodor SW, Augsburger JJ, Shields JA, et al. Natural history and management of advanced Coats disease. *Ophthalmic Surg*. 1988;19:89–93.
14. Nucci P, Bandello F, Serafino M, et al. Selective photocoagulation in Coats disease: ten-year follow-up. *Eur J Ophthalmol*. 2002;12:501–505.
15. Shapiro MJ, Chow CC, Karth PA, et al. Effects of green diode laser in the treatment of pediatric Coats disease. *Am J Ophthalmol*. 2011;151:725–731. e2.
16. Bergstrom CS, Hubbard GB. Combination intravitreal triamcinolone injection and cryotherapy for exudative retinal detachments in severe Coats disease. *Retina (Philadelphia Pa)*. 2008;28(3 suppl):S33–S37.
17. Li S, Deng G, Liu J, et al. The effects of a treatment combination of anti-VEGF injections, laser coagulation and cryotherapy on patients with type 3 Coats disease. *BMC Ophthalmol*. 2017;17:76.
18. Ray R, Barañano DE, Hubbard GB. Treatment of Coats disease with intravitreal bevacizumab. *Br J Ophthalmol*. 2013;97:272–277.
19. Zhao Q, Peng XY, Chen FH, et al. Vascular endothelial growth factor in Coats disease. *Acta Ophthalmol*. 2014;92:e225–e228.
20. Gaillard MC, Mataftsi A, Balmer A, et al. Ranibizumab in the management of advanced Coats disease stages 3B and 4: Long-term outcomes. *Retina (Philadelphia Pa)*. 2014;34:2275–2281.
21. Villegas VM, Gold AS, Berrocal AM, et al. Advanced Coats disease treated with intravitreal bevacizumab combined with laser vascular ablation. *Clin Ophthalmol*. 2014;8:973–976.
22. Ramasubramanian A, Shields CL. Bevacizumab for Coats disease with exudative retinal detachment and risk of vitreoretinal traction. *Br J Ophthalmol*. 2012;96:356–359.

23. Zhang L, Ke Y, Wang W, et al. The efficacy of conbercept or ranibizumab intravitreal injection combined with laser therapy for Coats disease. *Graefes Arch Clin Exp Ophthalmol*. 2018;256: 1339–1346.
24. Imaizumi A, Kusaka S, Takaesu S, et al. Subretinal fluid drainage and vitrectomy are helpful in diagnosing and treating eyes with advanced Coats disease. *Case Rep Ophthalmol*. 2016;7:223–229.
25. Desai SR, Dayem OA, Chakravarti A, et al. Modified transscleral external drainage of subretinal fluid in high bullous exudative retinal detachment due to Coats disease. *Oman J Ophthalmol*. 2018;11:181–183.
26. Peng J, Zhang Q, Jin H, et al. A modified technique for the transconjunctival and sutureless external drainage of subretinal fluid in bullous exudative retinal detachment using a 24-G i.v. catheter. *Ophthalmologica*. 2017;238:179–185.