Skin Involvement in Juvenile Dermatomyositis Is Associated with Loss of End Row Nailfold Capillary Loops

RACHEL LYNNE SMITH, JOYCE SUNDBERG, ELI SHAMIYAH, ALAN DYER, and LAUREN M. PACHMAN

ABSTRACT. ***Objective.*** To determine associations of dermatological findings in children with juvenile dermatomyositis (JDM) with specific nailfold capillary (NFC) structural abnormalities.

Methods. Sixty newly diagnosed, previously untreated children who met the Bohan-Peter criteria for definite JDM were seen between 1993 and 2002. They were classified by duration of untreated disease and by a disease activity score (DAS) composed of separate subscores for dermatological (DAS skin) and musculoskeletal (DAS muscle) findings. Routine NFC measurements yielded the number of end row loops, arboreal (bushy), and dilated capillary loops. Laboratory testing included muscle enzymes, von Willebrand Factor Antigen, and neopterin.

Results. DAS skin, but not DAS muscle, was associated with NFC end row capillary loss (r_s = –0.394, p = 0.008). End row capillary loss (reflecting avascularity), arboreal (bushy), and dilated capillary loops (reflecting change in vascular morphology) were each associated with longer untreated symptom duration (r_s = –0.401, r_s = 0.534, r_s = 0.371).

Conclusion. End row capillary loss measured by NFC was associated with the dermatological, but not musculoskeletal manifestations of JDM, suggesting that damage to skin and muscle may each have distinct disease pathophysiology. In JDM, skin involvement indicates a vasculopathy that progresses with increasing duration of untreated disease and is not revealed by standard serological laboratory tests. We propose that the cutaneous manifestations of JDM are associated with vascular disease and warrant aggressive therapy. (J Rheumatol 2004;31:1644–9)

Key Indexing Terms:
NAILFOLD CAPILLAROSCOPY
JUVENILE DERMATOMYOSITIS
SERUM MUSCLE ENZYMES
VASCULITIS

Juvenile dermatomyositis (JDM) is a rare childhood illness with an estimated incidence of 3.1/million/year[1]. JDM is a systemic vasculopathy with the primary clinical disease occurring in the muscles and skin. The manifestations of JDM appear to be associated in part with genetic factors that regulate the production of tumor necrosis factor-α (TNF-α), a proinflammatory cytokine, fostering an unrelenting chronic course that may include pathological calcifications[2]. Early aggressive treatment with immunosuppressants greatly improves the outcome for these children[3,4]. However, some of the consequences of prescribed immunosuppressants warrant use that is as brief as clinically feasible[5]. The physician employs both clinical findings and laboratory tests to guide therapy, but routine laboratory data, such as serum concentrations of lactate dehydrogenase (LDH), serum glutamic oxalic transaminase (SGPT), aldolase, and creatinine phosphokinase (CPK), often normalize rapidly, despite clinical evidence of continued disease; thus it is imperative to establish more sensitive indicators of continuing tissue damage[6].

Evidence of muscle inflammation is often used as the basis for determining disease activity in children with JDM. Typical methods of evaluating myositis include clinical estimation of muscle weakness and laboratory tests for serum muscle enzymes. The JDM rash is requisite to meet the Bohan and Peter criteria for diagnosis[7], but the relationship between the rash and systemic vascular damage in JDM is relatively unexplored. One indicator of the vascular aspects of JDM is the nailfold capillary[8], which reveals a distinct pattern of capillary loss (capillary dropout), capillary dilation, and branching arboreal capillary loops (bushy loops),

From the Department of Pediatrics, Division of Immunology/Rheumatology, Northwestern University Feinberg School of Medicine; and the Department of Pediatrics, Division of Immunology/Rheumatology, Children's Memorial Hospital, Chicago, Illinois, USA.

Supported by the National Arthritis Foundation, Daniel J. Pachman and Vivian A. Pachman Dermatomyositis Research Fund, Marlene Apflebaum Foundation, and the Jack Pappas Fund. Dr. Smith is the recipient of an American College of Rheumatology Medical Student Award, 2002.

R.L. Smith, MD, Northwestern University Feinberg School of Medicine; J. Sundberg, RN, Northwestern University Feinberg School of Medicine, Department of Pediatrics, Division of Immunology/Rheumatology, Children's Memorial Hospital; E. Shamiyah, MS, Department of Medicine, Northwestern University Feinberg School of Medicine; A. Dyer, PhD, Department of Preventive Medicine, Northwestern University Feinberg School of Medicine; L.M. Pachman, MD, Department of Pediatrics, Division of Immunology/Rheumatology, Northwestern University Feinberg School of Medicine.

Address reprint requests to Dr. L.M. Pachman, Children's Memorial Medical Center, Box 212, 2300 Children's Plaza, Chicago, IL 60614. E-mail: pachman@northwestern.edu

Submitted September 17, 2003; revision accepted February 13, 2004.

often with adjacent areas of avascularity[9,10]. A child with JDM and relatively normal NFC patterns (Figure 1A) is compared with NFC photographs from a child with active JDM (Figure 1B). More extensive NFC changes have been linked to a chronic and damaging disease course[11,12].

In 60 children with untreated JDM we assessed associations of the extent and severity of the rash and muscle symptoms with laboratory data obtained at diagnosis. The laboratory data included NFC changes, serum muscle enzymes, von Willebrand factor (vWF) antigen (an indicator of endothelial cell damage), and serum neopterin (a T lymphocyte-dependent macrophage product). Additionally, the

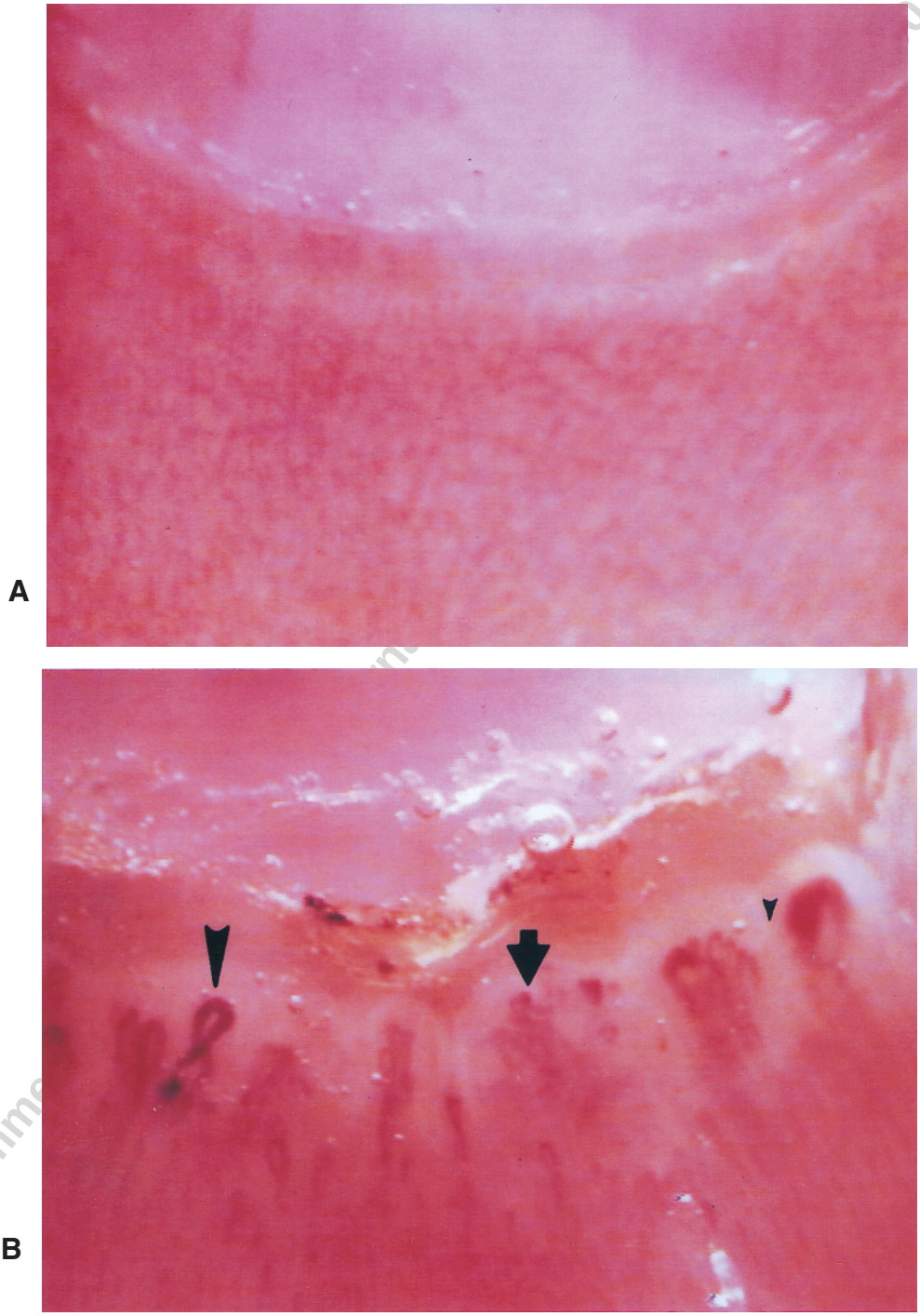

Figure 1. A. A relatively normal nailfold from a patient with JDM. B. An abnormal nailfold in a patient with JDM. Note the bushy loops (arrow, center), dilated loops (large arrowhead), and areas of avascularity (small arrowhead) (12× magnification).

association of untreated symptom duration with each of these variables was also examined.

MATERIALS AND METHODS

Patient population. All children with a diagnosis of Bohan-Peter "definite" JDM seen at Children's Memorial Hospital from 1993 through 2002 were eligible for this study. Children were excluded if they did not have NFC studies or if immunosuppressants were administered prior to the visit. Children were not admitted to the study if they had serological evidence of antibody to a myositis-specific antigen (MSA) such as JO-1 or SRP, or a myositis-associated antigen (MAA), such as SSA-SSB, Scl70, or RNP. Patients were 60 newly diagnosed, previously untreated children with JDM seen from 1993 to 2002 by one investigator (LMP), Table 1. Institutional Review Board approved consents were obtained from all parents and from the child, when age-appropriate.

NFC studies. All patients had NFC investigation at their first diagnostic outpatient visit. NFC studies were performed by one investigator (JS) and the disease activity scoring (DAS) by another (LMP), each blinded to the results of the other and obtained at different times and locations. These NFC studies[13] consist of freeze-frame video microscopy images of each of 8 fingers (thumbs are excluded). The images were analyzed for the number of arboreal branching loops (bushy loops), dilated loops, and the total number of loops (end row loops) per millimeter over the 8 digits[14]. Capillary dropout is indicated by a decreased number of end row loops per unit distance.

Disease activity score. One physician (LMP) determined the DAS for all patients. This is a validated clinical estimate of disease activity for both musculoskeletal and dermatological criteria[15] (Appendix). Nine points are given on the basis of clinical dermatological findings and 11 points based on musculoskeletal findings. In this study, the total DAS and the dermatologic (DAS skin) and musculoskeletal (DAS muscle) components were analyzed for associations with NFC measures. A higher DAS represents increasing disease activity as measured by physical therapist and physician evaluations as well as the Childhood Health Assessment Questionnaire[16,17].

Laboratory testing. At each visit, standard blood tests were conducted, including CPK, LDH, AST, and aldolase, in a single hospital laboratory[18] (Children's Memorial Hospital). vWF:Ag was derived by measurement of light absorbance observed by a suspension of micro-latex particles coated with specific antibodies. Neopterin, a T cell-dependent macrophage-derived factor released during the cellular immune response, was determined by commercial ELISA (Brahms Diagnostica, Hennigsdorf, Germany) according to manufacturer's recommendations[19].

Statistics. Univariate analyses and basic frequencies were used to initially analyze the data, followed by analysis using Spearman rank-order correlation coefficients.

Table 1. The demographics of this group of untreated children with JDM are similar to previous studies[1]. Ratio of girls to boys, 3.6.

	n (%)	Age at Diagnosis, median yrs (range)	Untreated Disease Duration, mo median yrs (range)
Male	12 (20)	4.0 (2.6–17.8)	0.44 (0.13–2.81)
Female	48 (80)	6.7 (2.2–21.0)	0.44 (0.30–8.61)
Ethnicity			
White	47 (78)	5.9 (2.2–21.0)	0.46 (0.03–6.66)
Hispanic	10 (17)	8.8 (3.1–15.2)	0.40 (0.14–8.61)
Black	3 (5)	7.9 (3.2–11.5)	0.27 (0.17–0.50)
Total	60	6.1 (2.2–21.0)	0.44 (0.03–8.61)

RESULTS

Disease activity scores. The patient group was 80% female, 78% white, 17% Hispanic, and 5% black (Table 1). Ages ranged from 2.2 to 21.3 years (mean 7.3, median 6.1 yrs). The median duration of untreated symptoms, from the first definite recognition of rash and/or weakness to the diagnosis of JDM, was 0.44 years (range 0.03–8.61 yrs). The 60 children had a mean total DAS score of 10.9 (range 3–17), with a mean skin score of 5.7 (range 0–9) and a mean muscle score of 5.0 (range 0–11), which documented that the untreated children in this study had active clinical symptoms.

NFC measurements. Each NFC was analyzed for the number of bushy loops and dilated loops, and the total end row loops per millimeter. The mean end row capillary loop number/mm was 5.8 ± 1.7 SD (range 3.1–10.3); the mean number of bushy loops/mm was 0.14 ± 0.18 (range 0–0.83); and the mean number of dilated loops was 1.3 ± 0.60 (range 0.17–3.08). A previous study of 13 healthy children (average age 7.2 yrs) in our clinic found a mean end row capillary loop of 7.8/mm[13,14]. The number of end row capillary loops/mm was not associated with muscle weakness (Figure 2A), but was inversely associated with the extent and severity of cutaneous involvement (r_s = –0.364, p = 0.008; Figure 2B).

Capillary loop dropout is associated with duration of untreated disease. The duration of time the child had untreated disease was determined by assessing the amount of time between the first definite symptom of JDM (rash and/or weakness) noted by the parents/guardian and the diagnostic evaluation, which included NFC measurement. Greater symptom duration prior to therapy was associated with worsening NFC structure, as indicated by increased bushy and dilated loops (r_s = 0.543, p < 0.0001; r_s = 0.371, p = 0.0038, respectively), as well as end row capillary loop dropout (r_s = –0.401, p = 0.0017) (Table 2). Negative associations of longer untreated symptom duration with abnormal laboratory values were seen: CPK (r_s = –0.388), LDH (r_s = –0.431), AST (r_s = –0.513), aldolase (r_s = –0.275), vWF:Ag (r_s = –0.284), and neopterin (r_s = –0.303). The longer the disease was untreated, the more likely was the laboratory data to normalize (Table 2). However, increased DAS total and DAS muscle score (but not DAS skin) were both associated with elevated levels of muscle enzymes, neopterin, and vWF:Ag (Table 3).

DISCUSSION

Nailfold capillary changes reflect systemic vasculopathy: NFC video investigation allows a noninvasive assessment of systemic capillaries, arterioles, and venules[20], and has been used to describe a number of diseases in which vascular structural abnormalities are found[21]. NFC dropout may be seen in Raynaud's phenomenon as an isolated complaint[10], or in idiopathic acrocyanosis[22], where giant dilated vessels

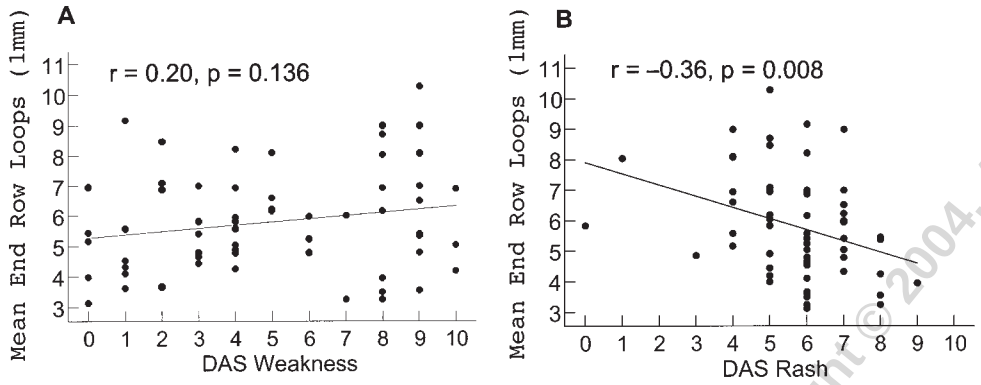

Figure 2. The association of the number of end row capillary loops with severity of rash (DAS rash, B), but not weakness (DAS muscle, A), in 60 children with untreated JDM.

Table 2. Correlations of disease activity scores (DAS) with nailfold capillary components in 60 children untreated at diagnosis of JDM. The data show that the longer the interval of untreated disease, the fewer end row capillary loops and the more frequent the findings of bushy loops and/or dilated capillary loops; note the negative correlation of laboratory assays with duration of untreated disease.

	Duration of Untreated Symptoms	
	Correlation Coefficient, r_s	p*
Nailfold Capillary Findings		
End row loops/mm	–0.401	0.0017
Bushy loops/mm	0.543	< 0.0001
Dilated loops/mm	0.371	0.0038
Laboratory values		
CPK	–0.388	0.0038
LDH	–0.432	0.0013
AST	–0.513	< 0.0001
Aldolase	–0.275	0.0487
vWF:Ag	–0.284	0.0436
Neopterin	–0.303	0.0327

* Spearman rank-order correlation.

Table 3. The laboratory values are associated with the DAS total and the DAS evaluation of muscle involvement, but not skin.

	DAS Total		DAS Muscle	
Laboratory Values	r_s*	p	r_s	p
CPK	0.288	0.0339	0.381	0.0041
LDH	0.442	0.0008	0.536	< 0.0001
AST	0.446	0.0007	0.543	< 0.0001
Aldolase	0.334	0.0146	0.422	0.0017
vWF:Ag	0.506	0.0001	0.543	< 0.0001
Neopterin	0.430	0.0017	0.391	0.0046

* Spearman rank-order correlation.

also occur[23]. Loss of end row capillary loops is also seen in association with systemic rheumatic vasculopathies such as scleroderma[24] and mixed connective tissue disease[10]. In patients with limited scleroderma, pulmonary hypertension was identified as a direct correlate of decreased NFC density[25]. Abnormal capillary shape includes apical dilation and branching vasculature, and it has been reported in diabetes mellitus[26] and familial Mediterranean fever[27].

DAS and NFC changes in untreated JDM. This study focused on the number of end row capillary loops and capillary morphology in children with untreated JDM. One report indicates that the severity of muscle damage on biopsy and NFC changes were closely associated[28]; however, nailfold abnormalities do not always correspond with the clinical findings of muscle weakness and serum muscle enzymes[29]. Although a delay in resolution of the damage and/or permanent damage to the nailfold vascular structure cannot be ruled out, the lack of association of NFC findings with these variables may be a function of a persistent vasculopathy that is independent of muscle weakness[12], and which may have a distinct pathophysiology of antigen presentation and elicited immune response[30].

The recent development and validation of a clinically based DAS that generates a DAS for skin and a separate DAS for muscle in JDM, as well as an overall total score[15], provides new insight into the relevance of NFC changes to the symptoms characteristic of JDM. The data presented here document that an elevated DAS skin is associated with nailfold end row capillary loop dropout. While considered a cosmetic challenge, rash presenting without muscular weakness is often not regarded as indicative of disease activity by many physicians, and therefore remains untreated. Our results suggest that the JDM rash may be a visible sign of a persistent vasculopathy that, if left untreated, may lead to longterm complications. Currently, there are limited data to support this conjecture, and studies are under way to obtain evidence concerning disease outcome. JDM patients with rash and without muscle weakness treated only with topical corticosteroids have a higher rate of calcinosis[31], although there appear to be exceptions to this observation[32]. The severity of the rash is associated with gastrointestinal vasculopathy and decreased absorption of oral steroid. This decreased bioavailability can be countered by intravenous corticosteroid administration[33].

Persistence of rash following treatment cessation also appears to be associated with the development of pathological calcifications (personal observation, LMP). The laboratory results support the traditional belief that serum muscle enzymes are an indication of the severity of muscle involvement, as shown by the associations between these values and the total DAS and DAS muscle. Our analysis shows, in contrast, that elevated muscle enzymes, vWF:Ag, and neopterin do not parallel DAS skin or NFC changes.

A preliminary report studied nailfold capillaries in 38 children with typical JDM and concluded that the NFC changes reflected a systemic vasculopathy in both skin and muscle[34]. There are several important differences in the study design that might account for the different conclusions, for in that report data were not collected for either duration of untreated disease or the serological subcategories (MAA, MSA) of children with both myositis and skin involvement. All our children had only JDM, those with MSA or MAA were excluded from the study. Finally, the earlier abstract[34] does not state if the children had been treated. All the data in this study were from untreated children with JDM.

Comparison with data from controls. In previous studies of NFC, control children without JDM did not have the decreased number of bushy loops, dilation, or dropouts seen in children with JDM. The same investigators found that the age of the child had an effect on the diameter of arterial and venous vessels, which increases with age, but not on the variables considered in this report — capillary density and apical or loop diameters[35]. This study benefited from having all NFC studies as well as all DAS evaluations performed by the same person, controlling for interobserver differences, and these measurements were internally consistent. Unlike another report that did not show a relationship between cutaneous changes and nailfold abnormalities[36], our data were derived from a larger number of children with untreated JDM.

Duration of untreated disease and NFC changes in JDM. Our center previously reported that a longer duration of untreated disease is associated with an increased number of NFC bushy loops[37]. With the increased number of patients in this study we are now able to determine that these changes include evidence for both dropout of the capillaries and dilation of the remaining capillary structures. Additionally, the routine tests for disease activity (muscle enzymes) normalized with increasing duration of active disease, regardless of initial DAS. This may indicate immunologic evolution over time, as reported in muscle biopsy studies[38]. Inasmuch as this study is a cross-sectional analysis, it is clear that longitudinal data in an initially untreated cohort of children are needed to verify this impression.

JDM rash is associated with vasculopathy. We conclude that 2 variables in the NFC assessment, end row capillary number and terminal loop vascular bush formation, are associated with severity of the rash and duration of untreated disease, but not muscle symptoms, in children with JDM before administration of therapy. This finding suggests that persistent rash may indicate ongoing vascular inflammation. The traditional laboratory tests (serum concentrations of muscle derived enzymes) do not reflect these capillary changes. This report confirms that study of the nailfold capillaries is an effective and noninvasive method to examine vascular disease activity in JDM.

ACKNOWLEDGMENT

We are indebted to the children and families who participated in this study. We thank Kathy Abbott, RN, for editing support, and Dr. James Sinacore for additional data analysis.

APPENDIX

The Disease Activity Score[15] (DAS) for examination of children with JDM.

	Score
Description of Skin Involvement: 0 – Absent or resolved completely 1 – Atrophic changes only 2 – Erythema (mild) 3—Erythema (moderate) 4 – Erythema (severe) 8 – Data not obtained	**0 – 4**
Distribution of Skin Involvement: 0 – None 1 – Focal (including areas of joint related skin) 2 – Diffuse (including extensor surfaces of limbs shawl areas) 3 – Generalized (including trunk involvement)	**0 – 3**
Vasculitis: (If any present here then score 1 for this section) a. Eyelid erythema _____ _____ b. Eyelid blood vessel dilation _____ _____ c. Eyelid blood vessel thrombosis _____ _____ d. Nailfold erythema (cuticles) _____ _____ e. Nail bed vessel telangiectasia _____ _____ f. Palate vessel dilation (Palate) _____ _____ g. Other _____ _____ (Absent / Present)	**0 – 1**
Gottron's papules: (If any present here then score 1 for this section) 0 – Absent 1 – Mild 2 – Moderate 3 – Severe	**0 – 1**
Weakness: (One point per weakness area noted) a. Neck flexor 1 2 3 4 5 (-) (+) _____ _____ b. Unable to clear scapula _____ _____ c. Upper proximal muscle weakness 1 2 3 4 5 (-) (+) _____ _____ d. Lower proximal muscle weakness 1 2 3 4 5 (-) (+) _____ _____ e. Gower's sign (assisted/unassisted) _____ _____ f. Abnormal gait _____ _____ g. Difficulty swallowing _____ _____ h. Nasal speech _____ _____ (Yes / No)	**0 – 8**
Functional Status: 0 – Normal function, able to attend school, keeps up with friends 1 – Mild limitations, tires after walking several blocks, general fatigue 2 – Moderate limitations, requires assistance with stair-climbing, ADL's 3 – Severe limits, wheelchair bound, unable to attend school, climb stairs, etc.	**0 – 3**
Total Disease Activity Score (DAS)= 0 – 20	

REFERENCES

1. Mendez EP, Lipton RB, Dyer A, et al. US incidence of JDM 1995-1998: results from the NIAMS Registry. Arthritis Rheum 2003;49:300-5.

2. Pachman LM, Liotta-Davis MR, Hong DK, et al. TNFα-308A allele in juvenile dermatomyositis: association with increased production of tumor necrosis factor alpha, disease duration, and pathologic calcifications. Arthritis Rheum 2000;43:2368-77.
3. Callen AM, Pachman LM, Hayford JR, Chung A, Ramsey-Goldman R. Intermittent high-dose intravenous methylprednisolone (IV pulse) therapy prevents calcinosis and shortens disease course in juvenile dermatomyositis [abstract]. Arthritis Rheum 1994;37 Suppl:R10.
4. Fisler RE, Liang MG, Fuhlbrigge RC, Yalcindag A, Sundel RP. Aggressive management of juvenile dermatomyositis results in improved outcome and decreased incidence of calcinosis. J Am Acad Dermatol 2002;47:505-11.
5. Klein-Gitelman MS, Pachman LM. Intravenous corticosteroids: adverse reactions are more variable than expected in children. J Rheumatol 1998;25:1995-2002.
6. Pachman LM. Imperfect indications of disease activity in juvenile dermatomyositis. J Rheumatol 1995;2:193-7.
7. Bohan A, Peter JB. Polymyositis and dermatomyositis. N Engl J Med 1975;292:344-7,403-7.
8. Maricq H, Leroy C. Patterns of finger capillary abnormalities in connective tissue disease by "widefield" microscopy. Arthritis Rheum 1973;16:619-28.
9. Kenik JG, Maricq HR, Bole GG. Blind evaluation of the diagnostic specificity of nailfold capillary microscopy in the connective tissue diseases. Arthritis Rheum 1981;24:885-91.
10. Lee P, Sarkozi J, Bookman AA, Keystone EC, Armstronh SK. Digital blood flow and nailfold capillary microscopy in Raynaud's phenomenon. J Rheumatol 1986;13:564-9.
11. Silver RM, Maricq HR. Childhood dermatomyositis: serial microvascular studies. Pediatrics 1989;83:278-83.
12. Nussbaum DI, Silver RM, Maricq HR. Serial changes in nailfold capillary morphology in childhood dermatomyositis. Arthritis Rheum 1983;26:1169-72.
13. Pachman LM, Sundberg J, Kinder J, Maduzia L, Daugherty C. Nailfold capillary studies in children with pediatric connective tissue diseases: systemic lupus erythematosus, juvenile dermatomyositis, Raynaud's phenomenon — comparison with data from normal children [abstract]. Arthritis Rheum 1996;39 Suppl:R14.
14. Pachman LM, Sundberg J, Maduzia L, Daugherty C, Litt D. Sequential studies of nailfold capillary vessels in 10 children with juvenile dermatomyositis: correlation with disease activity score but not von Willebrand factor antigen [abstract]. Arthritis Rheum 1995;38 Suppl:S361.
15. Bode RK, Klein-Gitelman MS, Miller ML, Lechman TS, Pachman LM. Disease activity score for children with juvenile dermatomyositis: Reliability and validity evidence. Arthritis Care Res 2003;49:7-15.
16. Huber AM, Hicks JE, Lachenbruch PA, et al. Validation of the Childhood Health Assessment Questionnaire in the juvenile idiopathic myopathies. J Rheumatol 2001;28:1106-11.
17. Feldman BM, Ayling-Campos A, Luy L, Stevens D, Silverman ED, Laxer RM. Measuring disability in juvenile dermatomyositis: validity of the Childhood Health Assessment Questionnaire. J Rheumatol 1995;22:326-31.
18. Lundberg I, Nessesmo I, Hedfors E. A clinical, serological and histopathological study of myositis patients with and without anti-RNP antibodies. Semin Arthritis Rheum 1992;22:127-38.
19. De Benedetti F, De Amici M, Aramini L, Ruperto N, Martini A. Correlation of serum neopterin concentrations with disease activity in juvenile dermatomyositis. Arch Dis Child 1993;69:232-5.
20. Pangratis N. Diagnostic investigation using vital capillary microscopy and dynamic capillaroscopy. Clin Hemorheol Microcirc 1997;17:371-83.
21. Blockmans D, Beyens G, Verhaeghe R. Predictive value of nailfold capillaroscopy in the diagnosis of connective tissue diseases. Clin Rhematol 1996;15:148-53.
22. Cannas F, Binaghi F. Nailfold capillaroscopy and laser Doppler flowmetry during standardised cold challenge to evaluate capillary pattern and digital flow in idiopathic acrocyanosis. Panminerva Med 2002;44:123-7.
23. Monticone G, Collona L, Palermi G, Bono R, Puddu P. Quantitative nailfold capillary microscopy findings in patients with acrocyanosis compared with patients having systemic sclerosis and control subjects. J Am Acad Dermatol 2000;42:787-90.
24. Stauder A, Hunziker T, Lutolf O, Schmidli J, Chen D, Mahler F. Quantitative nailfold capillary microscopy in cutaneous and systemic lupus erythematosus and localized and systemic scleroderma. J Am Acad Dermatol 1991;24:941-5.
25. Ong YY, Nikoloutsopoulos T, Bond CP, Smith MD, Ahern MJ, Roberts-Thomson PJ. Decreased nailfold capillary density in limited scleroderma with pulmonary hypertension. Asian Pac J Allergy Immunol 1998;16:81-6.
26. Fahrig C, Breitinger L, Heidrich H. Vital capillary microscopic findings in the nailfold of patients with diabetes mellitus. Vasa 2000;29:258-63.
27. Dinc A, Melikogu M, Korkmaz C, Fresko I, Özdogan H, Yazici H. Nailfold capillary abnormalities in patients with familial Mediterranean fever. Clin Exp Rheumatol 2001;19:S42-4.
28. Spencer-Green G, Schlesinger M, Bove KE, et al. Nailfold capillary abnormalities in childhood rheumatic diseases. J Pediatr 1979;102:341-6.
29. Pachman LM, Mendez E, Kanuru J, Sundberg J, Miller CH, Kinder J. Nailfold capillary studies in 50 untreated children with juvenile dermatomyositis [abstract]. Arthritis Rheum 1998;41 Suppl:S265.
30. Tezak Z, Hoffman EP, Lutz JL, et al. Expression profiling in DQA1*0501 children with juvenile dermatomyositis: A novel model of pathogenesis. J Immunol 2002;168:4154-63.
31. Eisenstein DM, Paller AS, Pachman LM. Juvenile dermatomyositis presenting with rash alone. Pediatrics 1997;100 Pt 1:391-2.
32. Plamondon S, Dent PB. Juvenile amyopathic dermatomyositis: results of a case finding descriptive survey. J Rheumatol 2000;27:2031-4.
33. Daru J, Fedczyna T, Ngai K-N, Pachman LM. Pharmacokinetics studies show decreased absorption of oral methylprednisolone compared with intravenous methylprednisolone in rheumatic disease patients with active vasculitis [abstract]. Pediatr Res 2000;47:91.
34. Feldman BM, Rider LG, Dugan L, Millwer FW, Schneider R. Nailfold capillaries as indicators of disease activity in juvenile idiopathic inflammatory myopathies [abstract]. Arthritis Rheum 1999;42 Suppl:S181.
35. Herrick A, Moore T, Hollis S, Jayson MIV. The influence of age on nailfold capillary dimensions in childhood. J Rheumatol 2000;27:797-800.
36. Spencer-Green G, Crowe WE, Levinson JE. Nailfold capillary abnormalities and clinical outcome in childhood dermatomyositis. Arthritis Rheum 1982;25:954-8.
37. Pachman LM, Mendez E, Lechman T, Sundberg J, Shamiyeh E, Dyer A. The rash of juvenile dermatomyositis is associated with derangement of capillaries [abstract]. Arthritis Rheum 2000;43 Suppl:S380.
38. Pachman LM, Fedczyna TO, Lutz JL, Caliendo J, Lechman T, O'Gorman MRG. Increased CD8+ and CD56+ lymphocytes in untreated juvenile dermatomyositis muscle biopsies are associated with a short compared with a long disease duration [abstract]. Arthritis Rheum 2000;43 Suppl:772.