Peripheral Neuropathy in Juvenile Diabetes

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SUMMARY

In order to study the incidence of diabetic peripheral neuropathy in children, nerve conduction studies and complete neurological examinations were performed on 107 unselected diabetic children below seventeen years of age. Motor conduction velocity of the ulnar, median, and peroneal nerves and sensory "conduction velocity" of the median nerves were measured by electromyographical technics. On the basis of the results of the electrophysiological and neurological examinations, eleven patients were considered to have definite evidence of peripheral nerve disease, twenty-three had equivocal findings, and seventy-three had no demonstrable abnormalities. The diabetic children with definite evidence of peripheral neuropathy had a longer duration of diabetes mellitus, a later age at onset of the disease, and were older at the time of examination than those patients without evidence of peripheral nerve disease. Those children with neuropathy were also thought to have poorer control of diabetes than those without neuropathy, but this was difficult to evaluate because of the interrelationship of the control factor with the duration of the disease. Three patients were found to have diabetic angiopathy; one had unequivocal, one equivocal and one no signs of neuropathy. DIABETES *15*:411-18, June, 1966.

An overwhelming number of reports have appeared about the clinical picture, classification, and incidence of neuropathy in diabetes mellitus. Most of these papers deal with adults only, or do not state whether or not children were included. The scarcity of reports on peripheral neuropathy in diabetic children would suggest a lower incidence of neuropathy in them than in diabetic adults. However, in a study limited to children below sixteen years of age, Lawrence and Locke,[1] over an eighteen-month period, found thirteen diabetics with evidence of neuropathy. Their material was partly selected and contained several patients who were examined because of symptoms relating to the peripheral nervous system. Gamstorp[2] showed that unselected diabetic children had a lower conduction velocity of peripheral nerves than normal age-matched controls. However, this was only apparent when means calculated for each group of children were compared. Few individual diabetic values were abnormal.

In order to establish the general prevalence of diabetic neuropathy, it was decided to examine a large, unselected group of children with diabetes mellitus. Complete neurological examinations and measurements of conduction velocities of peripheral nerves were performed. The latter method does not require the patient's cooperation and therefore is less subjective than the clinical examination. With this technic it is also possible to measure subclinical evidence of damage to the peripheral nerves. The information obtained from these studies could then be compared with factors which might have an etiological relationship to the diabetic neuropathy, i.e., age of onset, duration, control of the diabetes, etc.

MATERIALS AND METHODS

One hundred and seven juvenile diabetics were studied, of whom seventy-one were American and thirty-six Swedish. All were under seventeen years of age at the time of investigation. The patients were selected from the private practice of one of us (H.S.T.), the Diabetes Out-Patient Clinic of the Children's Memorial Hospital, Chicago, Ill., and the Department of Pediatrics, University Hospital of Lund, Sweden.

The care received by both groups of patients was roughly equivalent. All American patients received Lente or NPH insulins alone or in combination with Regular Insulin, while the Swedish children received Lente alone or a combination of Semilente and Lente in two divided doses. A few patients in the Swedish group were using Rapitard insulin,* in one or two daily injections. In both groups the dietary regimen was calculated by the same principles. The daily caloric intake at one year of age was 1000 cal. and this was increased by 100 cal. for each subsequent year. The maximum intake in girls was 2200 cal. and in boys 3000 cal. The weighed daily diet consisted of 2 to 4 gm. of protein per

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*Rapitard (Novo) is a biphasic insulin consisting of a combination of a quick-acting soluble insulin and a separate long-acting component, specific insulin crystals.

kilogram of body weight, and the carbohydrate to fat ratio was 2:1. Exercise was not only unrestricted, but recommended. Details of the routine of management may be found elsewhere.[3]

In all cases the urine was tested regularly for glucose and ketone bodies. Fasting blood sugar, blood cholesterol, and twenty-four-hour quantitative urine glucose were determined every four to six months in the American children and every two to three months in the Swedish children. The criteria used for evaluation of control are as follows:

Good control—To be considered in good control the patients had to meet four of the following criteria:

(1) Growth and development normal or high percentile for age.
(2) Urine free of glucose and acetone at least 75 per cent of the time.
(3) Twenty-four-hour quantitative urine glucose of 12 gm. or less.
(4) No hospitalizations except for the initial admission or for treatment of severe infections.
(5) Normal fasting blood sugar, or a two-hour postprandial blood sugar of less than 150 mg. per 100 ml.

Fair control—To be considered in fair control, patients had to meet four of the following criteria:

(1) Growth and development normal or greater than tenth percentile for age.
(2) Urine free of glucose and acetone 50 to 75 per cent of the time.
(3) Twenty-four-hour quantitative urine glucose of more than 12 gm. but less than 25 gm.
(4) No more than one hospitalization per year for control of diabetes.
(5) Fasting blood sugar up to 200 mg. per 100 ml., or a two-hour postprandial blood sugar between 150 and 250 mg. per 100 ml.

Poor control—Those patients who failed to meet the criteria for good and fair control were considered to be poorly controlled. These criteria included:

(1) Growth and development below tenth percentile for age.
(2) Glycosuria more than 50 per cent of the time.
(3) Twenty-four-hour urine glucose greater than 25 gm.
(4) More than one hospitalization per year for control of diabetes.
(5) Fasting blood sugar of more than 200 mg. per 100 ml. or a two-hour postprandial blood sugar of more than 250 mg. per 100 ml.

Complete neurological examination was performed by one examiner (S.S.) on all of the American children. The Swedish children were examined neurologically by several different resident physicians, and pertinent findings were checked by one examiner (G.E.). Ophthalmoscopy was performed on all the children. Urine was always checked for albumin.

A DISA electromyograph with a Grass stimulator was used for the measurement of peripheral nerve conduction velocity in the Swedish children. A TECA electromyograph model B with a Grass stimulator was used for the American children; however, the examiner (I.G.) and the technics were the same for both groups. Motor nerve conduction velocities of the ulnar, median and peroneal nerves were measured bilaterally in all children. The method for determining motor nerve conduction velocity, described by Hodes et al.[4], was used with small modifications. The methods of Dawson[5] and Gilliatt and Sears[6] were used to determine the latency of the sensory median nerves in the hand. Median nerve terminals were stimulated at the index finger and the nerve potentials were recorded at the wrist. Latency and distance were measured and a "conduction velocity" calculated. The measured latency was corrected for decreased skin temperature: 0.1 msec. was subtracted per degree (C°) below normal. The term sensory "conduction velocity" is used within quotation marks to stress that it does not represent the true nerve conduction velocity.

Details about the motor and sensory methods and the normal values in children have been reported previously by some of the present authors.[7,8] The normal conduction velocity values obtained in those studies will serve as controls for comparison with the diabetic children.* The range of values, in meters per second, considered border line low in each age-group is given in table 1; values below this range were considered to be definitely abnormal. Because of inherent errors in the methods, a border line range is preferable to a definite limit between normal and abnormal values. Sensory conduction was studied over a more distal segment of nerve than motor conduction, and the measured sensory latency includes the time necessary for the stimulus to excite the nerve terminals through the skin. These factors account

TABLE 1

Range of conduction velocity considered border line low in different age-groups

	Motor conduction velocity (m./sec.)			
	age			
	4-12 months	1-3 years	3-8 years	8-16 years
Ulnar nerve	35-39	40-44	45-49	50-54
Median nerve	25-29	35-39	40-44	45-49
Peroneal nerve	30-34	40-44	40-44	40-44
	Sensory "conduction velocity" (m./sec.)			
Median nerve finger to wrist	15-19	20-24	24-28	28-32

*One measurement was performed on each nerve both in the normal material[7,8] and in the present material.

for the lower range of values in sensory conduction.

According to the results of the neurophysiological and clinical examinations the patients were classified into groups A, O, and B. Group A consisted of all patients showing definite evidence of damage to peripheral nerves, either on electrophysiological or neurological examination. The patients were considered to show definite electromyographic evidence of peripheral nerve disease if they had at least two abnormal values, or one abnormal value plus at least two border line values, or at least four border line values. The children were considered to have clinical evidence of peripheral neuropathy if the ankle jerks were absent.

Group O contained those patients having normal electromyographical findings and normal or questionable abnormal clinical findings. They were judged to have no electromyographic evidence of peripheral nerve disease when all measured values were normal, or no more than one border line low value was found. The remaining patients were considered to have equivocal electromyographic findings and were classified as group B.

Another group, C, contained all patients with definite or equivocal evidence of damage to the peripheral nerves on clinical examination, regardless of the electromyographic findings. Thus all patients in group C will also appear in groups A, O, or B. Mild impairment of vibratory sensation, position sense, and two-point discrimination, and slight decrease in deep tendon reflexes were considered to be equivocal findings. Although the equivocal clinical findings may represent mild involvement of sensory fibers in the legs, it was decided not to include those patients in the abnormal group A. The findings were minimal and the examination was difficult to perform or was unreliable in many of the younger children. Also it was not possible to make electrophysiological measurements of sensory conduction in the legs.

As the management of diabetes mellitus and the evaluation of the degree of control were the same in the American and Swedish children, they will be treated together, although many tables will give the figures for the two groups separately.

TABLE 2

General survey of the material

	A		B		O		Total
	Am	Sw	Am	Sw	Am	Sw	
Age at examination-years							
0-3	0	0	1	0	7	1	9
4-7	1	0	2	1	12	8	24
8-11	0	0	6	2	15	14	37
12-16	9	1	7	4	11	5	37
Sex							
M	4	1	9	3	18	18	53
F	6	0	7	4	27	10	54
Duration-years							
New	0	0	0	1	3	5	9
0-1	0	0	4	0	16	11	31
1-2	0	0	1	0	10	4	15
3-5	5	0	10	2	12	4	33
6-11	5	1	1	3	4	3	17
>11	0	0	0	1	0	1	2
Control							
Good	3	0	10	2	24	20	59
Fair	3	0	3	4	15	6	31
Poor	4	1	3	1	6	2	17
Family history							
Pos.	1	0	4	0	11	4	20
Neg.	9	1	11	7	34	24	86
Not known	0	0	1	0	0	0	1
Age at onset-years							
0-3	1	0	3	2	12	8	26
4-7	3	1	4	3	15	8	34
8-11	5	0	7	2	16	10	40
12-16	1	0	2	0	2	2	7
Evidence of angiopathy*							
Present	0	1	0	1	1	0	3
Absent	10	0	16	6	44	28	104
Total	10	1	16	7	45	28	107

*Microangiopathy (retinal and/or renal).
Am = American material
Sw = Swedish material

RESULTS

The findings in the total material are summarized in table 2. The age at examination varied between infancy and sixteen years, most of the children being over eight years of age. There was an equal sex distribution. The duration of diabetes mellitus was the interval between the original hospitalization and the date of examination. This varied between several weeks and fifteen years; in most cases it was less than five years. Seventeen patients were considered to be in poor control, thirty-one in fair control, and fifty-nine in good control. A positive family history of diabetes mellitus in the parents, siblings, or first cousins was obtained in twenty of the 106 patients in whom a family history was available. The age at onset was relatively evenly distributed between the different age-groups. Three children showed evidence of diabetic angiopathy, observed on ophthalmoscopy and/or the repeated finding of albuminuria; two were Swedish and one was American.

The pertinent data concerning all patients who were considered to have diabetic neuropathy and were classified in group A are shown in table 3. There were eleven children in this group; ten were American and one was Swedish. As in the group as a whole there were ap-

TABLE 3

Group A
Data concerning patients considered to have diabetic neuropathy
(Requirements: see text) compared with the average for Group O

Initials (Number=11)	Am Sw	Sex	Control	Family history	Age at onset (months)	Duration (months)	Age at exam (months)	Evidence of angiopathy
M.H.	Am	M	Poor	Pos.	11	73	84	Absent
J.Z.	Am	F	Poor	Neg.	61	113	174	Absent
J.M.	Am	M	Good	Neg.	92	77	169	Absent
L.R.	Am	F	Good	Neg.	146	29	175	Absent
L.K.	Am	M	Fair	Neg.	117	60	177	Absent
J.S.	Am	M	Good	Neg.	106	91	197	Absent
K.M.	Am	F	Poor	Neg.	122	63	185	Absent
K.F.	Am	F	Fair	Neg.	51	131	182	Absent
A.D.	Am	F	Fair	Neg.	134	47	181	Absent
M.Q.	Am	F	Poor	Neg.	104	61	165	Absent
P.-Å.N.	Sw	M	Poor	Neg.	50	120	170	Present
Average					90	79	169	
Average for group O					80	27	107	

Am = American material
Sw = Swedish material

proximately equal numbers of males and females. A high percentage of this group were classified as being in the poor or fair control groups. Only one of the three patients with angiopathy and one of the twenty with a positive family history belonged to group A. Average values, in months, for age at onset, duration, and age at examination are shown at the bottom of the table together with corresponding values for group O.

The data for patients in group B are shown in table 4. There was a total of twenty-three patients in this group;

TABLE 4

Group B
Data concerning patients considered to have equivocal signs of diabetic neuropathy
(Requirements: see text)

Initials (Number=23)	Am Sw	Sex	Control	Family history	Age at onset (months)	Duration (months)	Age at exam (months)	Evidence of angiopathy
A.M.	Am	M	Fair	Pos.	137	48	185	Absent
W.U.	Am	F	Fair	Pos.	100	57	157	Absent
F.S.	Am	M	Fair	Neg.	133	24	157	Absent
A.H.	Am	M	Poor	Neg.	44	25	69	Absent
J.H.	Am	M	Good	Neg.	156	21	177	Absent
Y.G.	Am	F	Good	Pos.	130	9	139	Absent
K.T.	Am	F	Poor	Neg.	93	39	132	Absent
M.H.	Am	M	Good	Not known	104	7	111	Absent
B.J.	Am	M	Good	Neg.	15	62	77	Absent
S.M.	Am	F	Good	Neg.	113	10	123	Absent
T.M.	Am	M	Good	Neg.	79	26	105	Absent
B.S.	Am	M	Good	Neg.	87	8	95	Absent
L.D.	Am	F	Good	Pos.	3	24	27	Absent
V.B.	Am	F	Poor	Neg.	24	156	180	Absent
M.H.	Am	M	Good	Neg.	92	35	127	Absent
H.F.	Am	F	Good	Neg.	126	24	150	Absent
E.J.	Sw	F	Good	Neg.	115	new	115	Absent
H.B.	Sw	M	Poor	Neg.	92	41	133	Absent
B.L.	Sw	F	Fair	Neg.	100	67	167	Absent
M.L.	Sw	F	Fair	Neg.	94	81	175	Absent
S.H.	Sw	M	Fair	Neg.	20	180	200	Absent
P.B.	Sw	M	Fair	Neg.	49	129	178	Present
L.P.	Sw	F	Good	Neg.	18	77	95	Absent
Average					84	50	134	

Am = American material
Sw = Swedish material

sixteen were American and seven Swedish. There was an equal distribution between males and females. Only one of the three children with angiopathy and four of the twenty with positive family history belonged to group B. There were many patients in the poor and fair control group classification, but the percentage of patients in group B in the poor classification was less than that of group A.

The data for group C, those patients who were considered to have abnormal or questionable abnormal neurological findings, are shown in table 5. Patients M.Q. and A.D. had absent ankle jerks and were considered to have definite evidence of peripheral nerve disease. The other thirteen patients had findings of mild impairment of sensory function in the legs and were considered to show equivocal evidence of peripheral nerve damage. It is interesting that none of the patients in this series had any symptoms suggesting peripheral neuropathy. In this group there were eleven females and four males; the significance of this disparity in sex ratio was not readily apparent. Most of the children were in the older age groups and six of the fifteen patients were in the poor control group. It must be emphasized that sensory nerve fibers in the legs were not studied electrophysiologically and cases with involvement of these fibers may have been missed. The significance of this factor appears to be small, as Mulder et al.[9] found only one patient with clinical evidence of polyneuropathy and a normal electromyogram out of thirty-one adult diabetics with peripheral neuropathy. The correlation between the electromyographical results and the neurological findings was good in our series; 66 per cent of those patients with definite or equivocal neurological abnormalities were also classified in the abnormal or border line abnormal EMG groups.

An effort was made to correlate possible etiological factors in the production of diabetic neuropathy with the results obtained from the neurological and electromyographical examinations. The most significant etiological factors appear to be duration of the diabetes, the age at onset of diabetes mellitus, and the degree of control of the disease. Primary concern was directed towards the elucidation of significant differences between the eleven abnormal members of group A and the seventy-three normal children of group O. Group B was also analyzed, but as the electromyographical findings were equivocal in this group, less importance was attached to the results of this analysis. For the purposes of comparison and statistical analysis, the duration of disease, age at onset, and age at examination were expressed in months rather than years.

From the bottom lines of tables 3 and 4 it is obvious that the duration of disease is longer in both groups A and B than group O. Both differences are statistically significant ($p < 0.01$). Because of this marked difference in duration the patients in group A are older than those in group O.

In order to investigate further the influence of the duration of disease an attempt was made to eliminate the effect of the other two variables. For each

TABLE 5

Group C

Data concerning patients with definitely or questionably abnormal neurological findings

Definitely abnormal: Absent deep tendon reflexes (Patients M.Q. and A.D.)
Questionably abnormal: Reduction in vibration, position sense, or two-point discrimination (the remaining patients)

Initials (Number=15)	Sex	Family history	Control	EMG group	Age at onset (months)	Duration (months)	Age at exam (months)
M.Q.	F	Neg.	Poor	A	104	61	165
A.D.	F	Neg.	Fair	A	134	47	181
K.M.	F	Neg.	Poor	A	122	63	185
J.S.	M	Neg.	Good	A	106	91	197
L.K.	M	Neg.	Fair	A	117	60	177
L.R.	F	Neg.	Good	A	146	29	175
J.H.	M	Neg.	Good	B	156	21	177
Y.G.	F	Pos.	Good	B	130	9	139
V.B.	F	Neg.	Poor	B	24	156	180
A.H.	M	Neg.	Poor	B	44	25	69
B.G.	F	Neg.	Fair	O	131	31	162
M.C.	F	Neg.	Poor	O	24	77	101
L.V.	F	Neg.	Good	O	62	70	132
P.G.	F	Neg.	Poor	O	138	30	168
K.B.	F	Neg.	Good	O	110	18	128
Average					103	53	156

child in groups A and B a child from group O was matched as closely as possible with regard to age at onset and control of the disease, and the mean values for the third variable, duration, were compared. There were the same number of good, poor, and fair controls in each group and the age at onset was paired for each individual and the total. The results are shown in table 6. The difference between group A and group O is significant ($p < 0.01$), as is the difference between group B and group O ($p < 0.05$).

The same method of analysis was used to evaluate the influence of the age of onset variable. The two groups were paired for control of the disease and the duration, and the results are shown in table 7. The age at onset was significantly ($p < 0.01$) higher in group A than in group O. No significant differences were found between group B and group O.

The influence of the control of the diabetes is much more difficult to evaluate. The paired technic used in the two previous tables could not be used to evaluate this factor because there were not enough children in group O with a combination of long duration and older age of onset to match the children in group A. In table 8 the patients are grouped according to the estimation of the degree of control. It is apparent that the percentage of poor and fair is greater in group A than in group O. However, there are fairly substantial numbers of patients in group O who have poor or fair control and do not have diabetic neuropathy. Another complicating factor is suggested by the observation that the poorly controlled patients in group O have a duration of sixty-eight months and the patients in good control in the same group only have a duration of fourteen months. This suggests the reasonable hypothesis that with longer duration of disease there is poorer control, regardless of the presence or absence of peripheral neuropathy. In order to evaluate this possibility the patients were divided into two groups, those with duration over sixty months and those with diabetes less than sixty months. The results are shown in table 9. Eighty-one per cent of those children with a duration over five years are in the poor and fair control groups, while only 33 per cent of those with shorter duration are in these two groups. Thus it is apparent that the degree of control is not an independent variable but is related to the duration of the disease. There are various reasons why those children with a longer duration of disease have a higher incidence of poor and fair degree of control. With longer duration these patients have more time to develop difficulties in the control of their disease process. Most of

TABLE 6

Influence of the duration of the disease when an attempt is made to eliminate the effect of age of onset and control (For details: see text)

Group	Number of patients	Age at onset (months)	Control	Duration (months)
A	11	90	Similar	79
O	11	90	Similar	24
B	23	84	Similar	50
O	23	84	Similar	29

TABLE 7

Influence of the age of onset of the disease when an attempt is made to eliminate the effect of duration and control (For details: see text)

Group	Number of patients	Duration (months)	Control	Age at onset (months)
A	11	79	Similar	90
O	11	79	Similar	37
B	23	50	Similar	84
O	23	50	Similar	70

TABLE 8

The material grouped according to control

Group	Number	Per cent of total in group	Age at onset (months)	Duration (months)	Age at exam (months)
Poor control					
A	5	46	70	86	156
B	4	18	62	65	129
O	8	11	53	68	121
Fair control					
A	3	27	101	79	180
B	7	30	90	83	174
O	21	29	72	40	112
Good control					
A	3	27	114	66	180
B	12	52	87	25	112
O	44	60	89	14	103

TABLE 9

Comparison between patients with more than sixty months duration of diabetes and those with shorter duration

	More than sixty months duration of diabetes Group				
Control	A	B	O	Total	Per cent
Poor	5	1	3	9	35
Fair	2	4	6	12	46
Good	2	2	1	5	19
	Duration of diabetes less than sixty months Group				
Control	A	B	O	Total	Per cent
Poor	0	3	4	7	9
Fair	1	3	15	19	24
Good	1	10	43	54	67

these children are entering adolescence and the associated emotional problems of this period contribute to the poorer care that they receive.

The results of these studies do not indicate that good diabetic control over a long period of time will prevent the development of peripheral neuropathy. On the contrary the data in table 9 suggest the opposite conclusion, although this suggestion cannot be evaluated statistically because of insufficient data. Of the five patients in the good control group with a duration of over sixty months, two were classified in group A, two in group B, and only one in the normal group, group O. It is likely that diabetic children with poorer control of their disease have a greater chance of developing diabetic peripheral neuropathy than those children with good control, but it is difficult to dissociate the effect of this etiological factor from the influence of the duration of the disease.

DISCUSSION

In this series the prevalence of peripheral neuropathy in diabetic children was eleven of 107 patients, or approximately 10 per cent of all children examined. Other authors have used the combination of electrophysiological studies and neurological examination to investigate the prevalence of diabetic neuropathy in children. Lawrence and Locke[1] found a prevalence of 16 per cent; of twenty-five patients under sixteen years of age, four were thought to have abnormal findings. There were many differences between those authors' cases and the present series. They examined only patients admitted to the hospital, made electromyographic measurement only on children over five years of age, examined fewer nerves in each patient, required only one abnormal conduction velocity value to classify the patient as having peripheral neuropathy, and did not give data concerning the management and control of the disease. Hoffman[10] found no evidence of peripheral neuropathy in the twenty-two diabetic children that he investigated. However, his material is too small to justify his statement that the occurrence of peripheral neuropathy in children is almost nil. The findings of peripheral neuropathy may have been missed because the neurological examinations were performed by different interns and residents as a routine procedure, and conduction velocity was measured in no more than two nerves.

Most of the studies on adult diabetics primarily contain patients who have been examined because of symptoms of peripheral neuropathy.[11-14] However, an unselected material published by Mulder et al.[9] contained 103 diabetics from eleven to seventy-nine years of age. As only four subjects were below twenty years of age, it appears reasonable to classify this group as an adult material. Of their sixty-eight patients with a duration of diabetes of ten years or less only thirty-three were free of signs of peripheral nerve impairment, and sixteen showed definite evidence of polyneuropathy. This prevalence is much higher than in our comparable series in children.

Sensory symptoms and signs are usually the most common findings in diabetic peripheral neuropathy.[15,16] These abnormalities, particularly those related to impaired vibratory sensation, are more common in the lower extremities than the upper. The results of our investigation are in general agreement with these previous observations. Two of our patients had absent ankle jerks. Thirteen had equivocal findings, with mild impairment in vibratory sensation, position sense and two-point discrimination in the lower extremities, and in no case were any of these sensory modalities absent. Collens et al.,[17] using mechanical technics, found impaired vibratory sensation in nine of twenty-eight unselected diabetic children. None of the children was below seven years of age and only seven were less than ten years old. No child below ten had impaired vibratory sensation. In our material, covering a wider age range, patients with abnormal or equivocal neurological findings were in the older age groups, had a longer duration of disease, poorer diabetic control, and a later age at onset.

Since the work of Fagerberg[18] many authors have considered diabetic neuropathy to be a manifestation of a specific diabetic angiopathy in the vasa nervorum of the peripheral nerves. However, others have postulated that the peripheral neuropathy is caused by metabolic disturbances inherent in the diabetic disease. Steiness[19] has shown that vibratory perception during ischemia is maintained longer in diabetes than in normals. After improvement of the metabolic state there was a normalization of vibratory perception. Gregersen[20] found a reduction of motor conduction velocity in diabetics with less than five years duration of disease and no signs of angiopathy. In the present study eleven of 107 diabetic children were found to have diabetic neuropathy and three diabetic angiopathy. Of the three patients with angiopathy, one had unequivocal, one equivocal, and one no signs of neuropathy. These findings do not speak in favor of a vascular origin of diabetic neuropathy.

Although factors other than the duration and the control of diabetes mellitus must play a role in the occurrence of peripheral neuropathy,[13,16] most investi-

gators agree that the incidence of neuropathy increases with increasing duration of the disease,[21] a conclusion supported by the present study. A higher incidence of peripheral neuropathy with longer duration and poorer control of diabetes was also reported by Collyer and Hazlett[22] in 100 diabetics with age of onset before sixteen years. In our material there was a higher prevalence of poor diabetic control in those patients with peripheral neuropathy, and it is probable that the poor control of the diabetes mellitus is a significant etiologic factor in peripheral nerve disease. The lower prevalence of neuropathy in children than in adults suggests that the risk of developing neuropathy may be greater for diabetics with a late rather than early onset of the disease. Our children with diabetic neuropathy had a significantly later age at onset and were older at the time of examination than those children without evidence of peripheral nerve disease.

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