NEUROPATHY IN CHILDREN WITH DIABETES MELLITUS*

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Neuropathy in individuals with diabetes mellitus is a common occurrence and has been related to the duration and control of the metabolic disorder (Rundles, 1945). On occasion, however, symptoms referable to the peripheral nervous system have been the prominent presenting complaint and have led to the search for and ultimate diagnosis of the associated alteration of glucose metabolism (Ellenberg, 1958; Garland, 1960). Although the clinical picture has been well delineated in adults, peripheral neuropathy in diabetic children has attracted little attention (Danowski, 1957).

Present Investigation

During an 18-months' period 15 children with diabetic neuropathy were studied. Four of these were obtained from a group of 25 children admitted consecutively to the hospital and described below. All were under the age of 16. Diagnosis of neuropathy was based on the findings of reflex loss, motor weakness, sensory impairment, absent axon reflex, and depressed motor-nerve conduction velocity; in no instance was the diagnosis entertained when fewer than two of these criteria were present. In 13 out of the 15 children examined the disorder was a peripheral polyneuropathy with its characteristic bilateral, symmetrical affection of the distal part of long nerves as manifest by depressed or absent ankle-jerks, mild to moderate weak-

ness of the small muscles of the feet, and a stocking-type sensory loss with a fading upper border. In two instances there was a bilateral motor mononeuropathy in which the affection was restricted to the distribution of the common peroneal nerve or its branches. In all patients general physical and neurological examinations were supplemented with routine laboratory investigations; measurement of motor-nerve conduction velocity was performed in all but two. The clinical and laboratory data of the 13 children with polyneuropathy are summarized in Table I.

Of particular interest in this group was one of a pair of twins. This girl (Table I, Case 2), 14 years old, had

TABLE II.—Motor-nerve Conduction Velocity in 16 Out of 25 Diabetic Children Admitted Consecutively to the Hospital

Case	Age (Years)	Duration Diabetes	Conduction Velocity (Meters Second)		
			Ulnar	Median	Peroneal
A	13	5 months	58.1	57.4	41.2
B	15	13 years	58.6	51.9	39.4
C	9	8 "	55.6	55.9	40.7
D	14	2 weeks	62.9	56.9	36.9
E	8	9 months	67.7	55.3	47.0
F	12	18 "	61.5	56.4	47.1
G	15	1 month	54.5	55.8	44.2
H	12	6 years	57.2	64.5	49.2
I	10	1 year	58.1	58.4	44.1
10	9	3 months	59.6	62.1	45.5
11	15	3 years	59.2	56.0	45.4
12	10	3 "	66.9	66.4	45.8
13	10	3 "	57.7	59.8	43.9
J	13	9 "	59.7	61.5	45.8
K	10	5 "	61.9	61.4	51.6
L	9	1 month	57.5	59.5	45.2

had diabetes mellitus for nine years, treated with diet and 38 units of insulin daily. She had noted occasional calf cramps, but was otherwise free from neurological symptoms. On examination she had mild bilateral weakness of extensor digitorum brevis and extensor hallucis longus, absent knee-jerks, depressed ankle-jerks, diminished perception of pinprick and temperature to the level of the lower one-third of the tibia, intact position and vibration sense, and an impaired axon reflex. Peroneal motor-nerve conduction velocity was 38.2 metres/second on the right side. Her twin sister had known diabetes mellitus of five years' duration, treated with diet and 36 units of insulin daily. This girl had been entirely free of neurological symptoms, and examination of the peripheral nervous system

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TABLE I.—Clinical and Laboratory Data in Thirteen Diabetic Children with Neuropathy

Case No.	Sex	Age (Yrs)	Duration Diabetes	Daily Insulin (Units)	Symptoms	Muscle Weakness (Bilateral)	Reflexes	Sensory (Pin and Temp.)	Axon Reflex	Admiss. Blood Sugar	Serum Cholesterol	Motor-nerve Conduction Velocity (Metres Second)		
										mg. 100 ml.		Ulnar	Median	Peroneal
1	M	15	4 years	60	None	E.H.	A.J. dim.	Dim. feet	—	371	214	55.0	60.1	44.6
2	F	14	9 "	38	Calf cramps	E.D.B.; E.H.	K.J. absent, A.J. dim.	Dim. lower legs and feet	O—calves	162	230	55.8	51.3	38.2
3	F	13	9 "	64	None	None	K.J., A.J. absent	Dim. distal arms and legs	"	282	256	—	—	—
4	F	10	2 months	26	"	"	K.J. dim., A.J. absent	Dim. legs and feet	"	181	241	55.5	52.4	46.4
5	M	6	1 month	16	"	"	K.J., A.J. absent	Dim. legs and feet	"	224	143	53.8	55.3	47.8
6	F	9	1 week	22	Calf cramps	"	K.J. dim.	Dim. feet	Intact	369	270	61.2	53.4	46.3
7	M	13	3 months	30	None	"	K.J., A.J. dim.	Dim. legs and feet	O—calves	170	274	65.4	58.1	—
8	M	8	6 weeks	24	Calf and thigh cramps; feet "asleep"	E.H.	K.J. absent, A.J. dim.	Dim. lower legs and feet	Intact	690	197	65.0	51.8	48.2
9	M	15	12 years	46	None	None	K.J. dim., A.J. absent	Intact	O—calves	180	184	—	—	—
10	M	9	3 months	10	"	"	K.J. absent	Dim. lower legs and feet	O—feet	300	—	59.6	62.1	45.5
11	F	15	3 years	50	Calf cramps	"	K.J. absent	Intact	Intact	255	185	59.2	56.0	45.4
12	F	10	3 "	22	None	"	A.J. dim.	Dim. lower legs and feet	"	300	194	66.9	66.4	45.8
13	M	10	3 "	28	Thigh and calf pains	"	K.J. absent, A.J. dim.	"	"	172	—	57.7	59.8	43.9

E.H. = Extensor hallucis longus. E.D.B. = Extensor digitorum brevis. A.J. = Ankle-jerk. K.J. = Knee-jerk. Dim. = Diminished.

revealed no evidence of neuropathy. Peroneal motor-nerve conduction velocity was 46.2 metres/second on the right side.

Mononeuropathy, which was of less frequent occurrence than polyneuropathy, was symptomatically more troublesome. The two children with mononeuropathy presented with motor symptoms.

Case 14

A 13-year-old girl was admitted to the hospital with a three-weeks history of shuffling gait and tripping over her feet. Symptoms of diabetes mellitus, including loss of weight, polyuria, polydipsia, and polyphagia, had been present for two to three months but had not been treated prior to admission. There was no history of injury. General physical examination revealed nothing abnormal; there was no evidence of retinopathy or nephropathy. The abnormal findings in the nervous system were confined to the lower extremities. There was a high-steppage gait with inability to walk on her heels and mild instability on attempting to walk on her toes. Strength in proximal legs was normal. There was complete inability to evert the foot or dorsiflex the foot or toes on the left and only faint movements were present on the right. Gastrocnemius, tibialis posticus, and flexor digitorum longus were of normal strength bilaterally. Reflexes were symmetrically present and the plantar response was flexor on the right with no response on the left. The peroneal nerves were normal to palpation at the head of the fibula. Sensory examination was normal.

Laboratory studies revealed a haematocrit of 40, a white-blood-cell count of 6,500/c.mm. and a blood urea nitrogen of 15 mg./100 ml. On admission the blood sugar was 321 mg./100 ml. and the serum cholesterol 292 mg./100 ml. The erythrocyte sedimentation rate was 12, and blood eosinophil count 200/c.mm. Cerebrospinal fluid showed two lymphocytes, negative Hinton reaction, and a total protein of 18 mg./100 ml. X-ray examination of the lumbosacral spine showed an epiphysitis of the first lumbar vertebra; a chest film was normal. Motor-nerve conduction velocities in metres per second were: right ulnar 61.5; right median 55.2; right peroneal 39.8; and left peroneal 38.9.

The diabetes was regulated with diet and 24 units of insulin daily. Examination three and six months after her admission to hospital showed progressive restitution of strength. Ten months after she presented there was no demonstrable weakness in either leg and no clinical evidence of peripheral nerve affection. At that time nerve-conduction velocities were: right peroneal 42.4 and left peroneal 41.3 metres/second.

Case 15

A 14-year-old boy with a six-weeks history of symptoms of diabetes mellitus complained of "needle-like pains" in the right ankle, aching in anterior thighs, and slapping of the feet, right more than left, for one week prior to admission. The foot-drop was noted to be worse at the end of the day. There was no history of injury. He had received no treatment for his diabetes prior to admission to hospital. General physical examination revealed a thin but otherwise healthy boy. There was neither retinopathy nor nephropathy. Examination of the nervous system revealed a mild facial asymmetry and mild bilateral ptosis. He was unable to walk on his heels. There was moderate weakness of dorsiflexion of the feet and toes, more marked on the right, with good strength on eversion bilaterally. Gastrocnemius, tibialis posticus, and flexor digitorum longus were strong bilaterally. Reflexes were present and normal throughout, and the plantar responses were flexor. The peroneal nerves were normal to palpation at the head of the fibula. Sensory examination was normal.

Laboratory examinations showed: haemoglobin 15 g./100 ml.; white blood count 8,000/c.mm.; blood urea nitrogen

15 mg./100 ml.; and negative blood Hinton reaction. The erythrocyte sedimentation rate was 8 and the blood eosinophil count 94/c.mm. On his admission the blood sugar was 335 mg./100 ml. and the serum cholesterol 192 mg./100 ml. A lumbar puncture revealed clear fluid under normal pressure with 14 red blood cells and a total protein of 53 mg./100 ml. Lumbosacral spine films were normal. Motor-nerve conduction velocities in metres per second were: right ulnar 55.3; right median 55.8; right peroneal 40.3; and left peroneal 38.9.

The patient was given a diabetic diet and placed on insulin; his general symptoms of diabetes mellitus cleared and he was discharged after one week in hospital on 36 units of insulin daily.

Examination four months after his admission showed improvement in gait and only mild weakness of extensor hallucis longus and extensor digitorum brevis. There were no abnormalities on sensory examination. Seven months after hospitalization there was still mild weakness of dorsiflexion of all toes bilaterally and a suggestion of a fading loss to pin and temperature on the feet and lower legs. Reflexes were normal. Motor-nerve conduction speeds were: right peroneal 42.4 and left peroneal 40.1 metres/second.

In order to assess the frequency of neuropathy in children, 25 patients under the age of 16 admitted consecutively to the hospital were examined. The age range was 18 months to 15 years. Diabetes mellitus had been present from two weeks to 13 years, with a median duration of 2.5 years. Motor-nerve conduction velocity in ulnar, median, and peroneal nerves was measured in 16 individuals (Table II); children of 5 years and under were not subjected to the procedure and two children, age 6 and 11 years, refused the test. Four of the 25 had clinical evidence of neuropathy (Table I, Cases 10 to 13) and four others (Table II, Cases A to D), without clinical evidence of neuropathy, had peroneal motor-nerve conduction velocities ranging from 36.9 to 41.2 metres/second, values which, in our laboratory, are abnormal (Lawrence and Locke, 1961). This incidence, as determined clinically or by measurement of motor-nerve conduction velocity, suggests that neuropathy is of frequent occurrence in diabetic children.

Summary

Fifteen children with diabetic neuropathy were studied. All were under the age of 16. The diagnosis was based on the findings of reflex change, weakness, sensory impairment, absent axon reflex, and decreased motor-nerve conduction velocity. Thirteen children had signs of a distal bilateral polyneuropathy. Two children had bilateral peroneal mononeuropathy.

In order to obtain an estimate of the frequency of occurrence of neuropathy in diabetic children, 25 patients under the age of 16 admitted consecutively to the hospital were studied. Four presented clinical evidence of a peripheral polyneuropathy and four others had depressed motor-nerve conduction velocity in the peroneal nerves, in the absence of clinical signs. This incidence suggests that neuropathy is of frequent occurrence in diabetic children.

REFERENCES

- Danowski, T. S. (1957). *Diabetes Mellitus with Emphasis on Children and Young Adults*, p. 482. Williams and Wilkins, Baltimore.
- Ellenberg, M. (1958). *Ann. intern. Med.*, **49**, 620.
- Garland, H. (1960). *Proc. roy. Soc. Med.*, **53**, 137.
- Lawrence, D. G., and Locke, S. (1961). *Arch. Neurol. (Chic.)*, **5**, 483.
- Rundles, R. W. (1945). *Medicine (Baltimore)*, **24**, 111.