Blood-Cell Velocity in the Nailfold Capillaries of Patients With Normal-Tension and High-Tension Glaucoma

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We compared the capillary blood-cell velocity in the fingertips of 30 patients with high-tension glaucoma, 30 patients with normal-tension glaucoma, and 30 control subjects by nailfold capillaroscopy. There were no measurable differences in the morphologic findings. The blood-flow velocity, however, was reduced significantly in the patients with normal-tension glaucoma compared with the control subjects ($P < .05$). This difference was especially pronounced after cold provocation ($P < .0005$). After cooling, 25 of 30 patients with normal-tension glaucoma had a blood standstill of 12 seconds or more, whereas only three of 30 control subjects and four of 30 patients with high-tension glaucoma had a measurable blood standstill.

Glaucoma is phenomenologically characterized by progressive excavation of the optic nerve head and visual field defects. The mechanisms that lead to the damage of the optic nerve head are not well understood. Clinical studies indicate that besides increased intraocular pressure, other factors might be involved. In addition to age, demographic, and genetic factors, mainly vascular and rheologic factors have been described.[1-7] An association between glaucoma and migraine[8] as well as between glaucoma and peripheral circulation[9-11] has been reported. We compared the nailfold capillary blood flow under baseline conditions as well as after local warming and cooling in patients with normal-tension glaucoma, patients with high-tension glaucoma, and control subjects.

Accepted for publication Feb. 11, 1991.

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Patients and Methods

We studied 30 patients with normal-tension glaucoma, 30 patients with high-tension glaucoma, and 30 control subjects (Table 1). Normal-tension glaucoma was defined as typical optic nerve head excavation and visual field defects with an untreated mean intraocular pressure of less than 21 mm Hg and a peak intraocular pressure of less than 25 mm Hg based on several diurnal pressure curves. High-tension glaucoma was defined as optic nerve head excavation and visual field defects with an untreated mean intraocular pressure greater than 24 mm Hg at repeated measurements.

We included patients with normal-tension glaucoma referred by other ophthalmologists to the University Eye Clinic during 1989 for clini-

TABLE 1
DEMOGRAPHIC DATA AND CLINICAL BACKGROUND OF CONTROL SUBJECTS AND PATIENTS*

	CONTROL SUBJECTS (N = 30)	PATIENTS WITH HIGH-TENSION GLAUCOMA (N = 30)	PATIENTS WITH NORMAL-TENSION GLAUCOMA (N = 30)
Sex (female: male)	18:12	17:13	16:14
Age (years)	59.2 ± 12.7	58.6 ± 11.9	60.6 ± 11.7
Pulse rate, sitting (per minute)	74.0 ± 14.5	73.0 ± 12.6	74.2 ± 10.1
Systolic blood pressure, sitting (mm Hg)	132.8 ± 20.4	127.1 ± 15.5	131.6 ± 23.9
Diastolic blood pressure, sitting (mm Hg)	82.8 ± 9.2	82.3 ± 9.7	82.5 ± 13.1

*Values given are mean ± standard deviation.

cal examination. The conditions were either newly diagnosed (20 of 30 patients) or the patients had progressive visual field loss (ten of 30). Five patients were taking beta-blockers, even though their intraocular pressure had never been increased.

For each patient with normal-tension glaucoma included, a patient with high-tension glaucoma and a control subject of the same age were selected. The patients with high-tension glaucoma were also referred to us by other ophthalmologists for examination because of increased intraocular pressure despite treatment, progressing visual field loss, or both. All patients were taking antiglaucoma medication, including beta-blockers (25 of 30), miotics (17 of 30), or epinephrine derivatives (five of 30). The systemic carbonic anhydrase-inhibitor therapy (four of 30) was discontinued for at least 14 days before the test.

The control group consisted of 11 staff members of the hospital and 19 patients referred to us for cataract surgery. They all had normal intraocular pressure and normal-appearing optic nerve heads.

Exclusion criteria for all groups were migraine, anemia, cardiovascular diseases, systemic hypertension and hypotension, diabetes mellitus, and collagen or vascular disorders. The three groups were matched by age. Blood pressure and pulse rate were influenced by the exclusion criteria. The three groups, however, resembled each other in this respect merely by chance. None of the subjects had been taking any systemic medication for at least two weeks before the examination.

The nailfold capillaries were studied with the help of an incident-light microscope attached to a television monitor.[11-13] To measure the diameter of the capillaries, photographs were taken from the monitor. To measure the capillary blood-cell velocity, the television pictures were videotaped and analyzed during playback by the flying-spot technique as previously described.[14,15]

The examinations were performed in a room with a constant temperature of 23 C. Before participating in the investigation, the subjects were acclimatized in this room for 30 minutes. Thereafter, the videotape pictures were made to measure the morphologic variables. Then, the baseline blood-cell velocity was measured. After immersion of the fingertip in a warm-water bath of 40 C for three minutes, the second reading was performed. The third measurement was made after cooling the observed skin area for 60 seconds by blowing decompressed carbon dioxide of approximately −15 C over the nailfold. The fourth and the fifth measurements were made after spontaneous recovery periods of one and two minutes, respectively.[12] In cases where the blood flow ceased during local cooling, the duration of the blood-flow standstill was measured in seconds. Such cases are called vasospastic.[11]

Results

To illustrate examples of the effect of cooling, photographs were taken from the videomonitor (Fig. 1). The morphologic characteristics of the individual capillaries were similar in the three groups. The arterial, venous, and crest diameters as well as the width of the loop were not

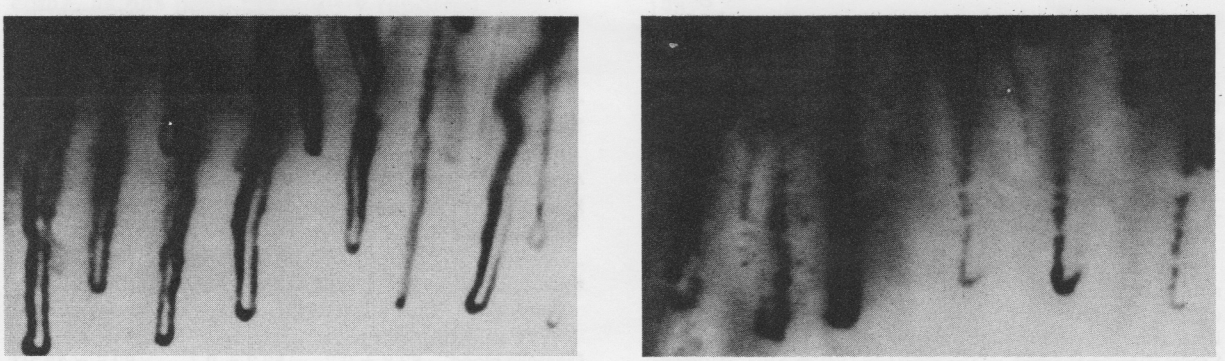

Fig. 1 (Gasser and Flammer). Photographs taken from the videomonitor demonstrating the nailfold capillaries after cold provocation. Left, A control subject with normal circulating erythrocytes. Right, Blood standstill and segmentation of the blood-cell column caused by flow stop after cooling (cold-induced vasospasm) in a patient with normal-tension glaucoma.

TABLE 2
MORPHOLOGIC FINDINGS ON NAILFOLD CAPILLARIES*

	CONTROL SUBJECTS	PATIENTS WITH HIGH-TENSION GLAUCOMA	PATIENTS WITH NORMAL-TENSION GLAUCOMA
Diameter (μm)			
Arteriolar	11.1 ± 2.1	11.0 ± 1.8	10.6 ± 1.8
Venular	13.0 ± 2.5	13.3 ± 2.3	12.7 ± 2.0
Crest	16.0 ± 3.4	16.3 ± 3.5	16.5 ± 2.9
Width	34.3 ± 5.8	33.9 ± 6.3	32.8 ± 5.1
Capillary density (number of nailfold capillary loops per mm)†	6.8 ± 1.2	6.0 ± 1.5	7.1 ± 1.8

*Values given are mean ± standard deviation.
†Significance level between control subjects and patients with high-tension glaucoma, P = .026.

significantly different (Table 2). The capillary density was slightly smaller in the high-tension glaucoma group than in the control group, which was statistically significant (P = .026). The capillary density in the normal-tension glaucoma group, however, was not significantly different from that in the control group.

The control group showed the well-known increase in the mean capillary blood-cell velocity after warming and a decrease after cooling the fingertip and during the recovery (Fig. 2). The patients with high-tension glaucoma showed the same basic dynamics (Fig. 2). In most instances, the patients with high-tension glaucoma had on the average a slightly slower capillary blood-cell velocity, although these differences were not statistically significant.

The reduction of the capillary blood-cell velocity, however, was more pronounced in the normal-tension glaucoma group. The differences from the control subjects were statistically significant in all instances (P < .05), especially after cold provocation (P < .0005). Three control subjects and four patients with high-tension glaucoma had a measurable blood-flow standstill (Fig. 3). Of the 30 patients with normal-tension glaucoma, however, only five patients had no blood-flow stop and 25 patients had a clear blood-flow standstill, the duration of which ranged between ten and 95 seconds.

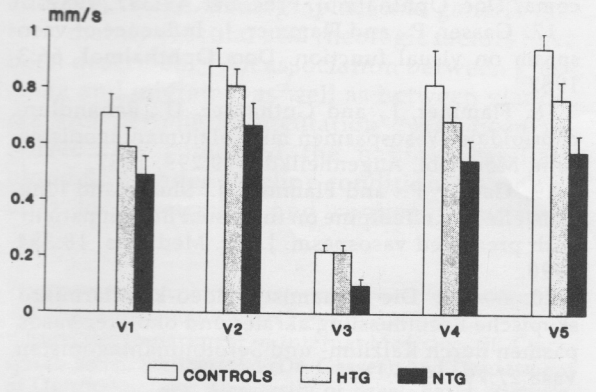

Fig. 2 (Gasser and Flammer). Blood-flow velocities of control subjects, patients with high-tension glaucoma (HTG), and patients with normal-tension glaucoma (NTG) at baseline (V1), after the warm-water bath (V2), after cooling (V3), and after recovery (V4 and V5).

Discussion

The peripheral blood flow in patients with high-tension and normal-tension glaucoma might be different from that in normal subjects. The capillary blood-cell velocity was on the

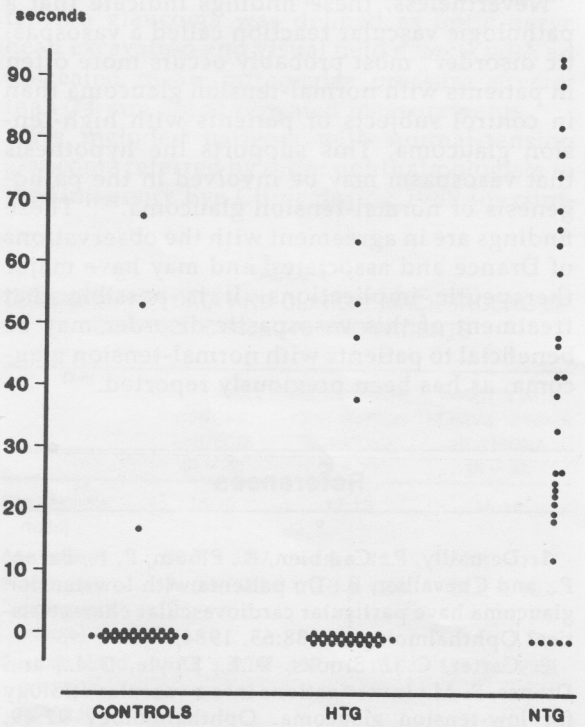

Fig. 3 (Gasser and Flammer). Duration (in seconds) of cold-induced blood-flow standstill in the control subjects, patients with high-tension glaucoma (HTG), and patients with normal-tension glaucoma (NTG).

average slightly slower in the patients with high-tension glaucoma than in normal control subjects, although this difference was not statistically significant. The normal-tension glaucoma group, however, had a more pronounced and statistically significant decrease in the capillary blood-cell velocity. The difference from the control subjects was especially evident after the cold provocation. The most striking finding, however, was the difference in blood-flow standstill after cooling. In this respect, patients with high-tension glaucoma and control subjects were essentially the same. The patients with normal-tension glaucoma, however, had a clear and statistically significant difference in blood-flow standstill.

It is difficult to know how much the population tested is representative of the total population. All the patients selected from our clinic were referred by other ophthalmologists. Some of these ophthalmologists knew that we had a special interest in vasospastic disorders. Therefore, we cannot exclude the possibility that the proportion of vasospastic cases in the population tested was slightly higher than that in an average population.

Nevertheless, these findings indicate that a pathologic vascular reaction called a vasospastic disorder[14] most probably occurs more often in patients with normal-tension glaucoma than in control subjects or patients with high-tension glaucoma. This supports the hypothesis that vasospasm may be involved in the pathogenesis of normal-tension glaucoma.[16,17] These findings are in agreement with the observations of Drance and associates[9] and may have major therapeutic implications. It is possible that treatment of this vasospastic disorder may be beneficial to patients with normal-tension glaucoma, as has been previously reported.[18-21]

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