Carpal-tunnel pressure

Riccardo Luchetti[1], Rudolf Schoenhuber[2], Giorgio De Cicco[3], Mauro Alfarano[1], Stefano Deluca[1] and Antonio Landi[1]

Using the constant infusion technique, we have measured the pressures within the carpal tunnel in 30 hands in patients with carpal tunnel syndrome and in 4 hands in control subjects. The mean pressure in the normal, control subjects was 13 mmHg and in the carpal tunnel syndrome patients 26 mmHg. In the normal subjects the pressures did not change along the canal, whereas in the patients the values in the middle section were 50 percent higher than the mean. Our results correspond to reports of computed tomography and magnetic resonance recordings of nonuniform dimension of the carpal tunnel.

The pressure in the carpal tunnel in acute nerve compressions was recorded by Bauman et al. (1981) and in chronic cases by Gelberman et al. (1981) and Werner et al. (1983). These previous investigations dealt with pressure measurements at only one level within the carpal tunnel. We report the pressures along the median nerve in its entire course in the carpal tunnel.

Subjects and methods

Pressure was measured within the carpal tunnel of 26 patients with idiopathic carpal tunnel syndrome and of 4 control subjects. Four patients had a bilateral carpal tunnel syndrome. The total number of hands with carpal tunnel syndrome was therefore 30. In all the patients the diagnosis of carpal tunnel syndrome was established by both clinical and neurophysiologic investigations. Twenty-five patients were female, 1 male; their mean age was 51 (35–77) years. The average duration of symptoms was 4 years (1 month–7 years). The mean age of the 4 control subjects (1 male and 3 females) was 48 (37–58) years. Polyneuropathy was excluded in both groups.

Both patients and controls were examined supine with the arm outstretched in 90°abduction and supination. The volar skin was anesthetized proximal to the distal wrist crease with 2 mL of 2 percent Carbocain. The skin and antebrachial fascia incisions of 1.5 cm were ulnar to the median nerve.

A radiopaque 0.9-mm, closed, rounded-tip nylon catheter with three 0.8-, 1.2-, and 1.7-cm side holes was gently introduced, without the aid of a needle, alongside the nerve until it crossed the distal border of the flexor retinaculum or had been advanced 5.0 cm. The skin incision around the catheter was left open because the dimension of the fascia incision corresponded to the size of the catheter. The catheter was then slowly retracted in 0.5 cm steps, and the pressures were recorded by a connected acquisition system built by one of the authors. Because the carpal tunnel may be considered an open compartment, a constant infusion technique, at 1.8 mL/h, was adopted for measuring the pressure.

In several patients it was not possible to introduce the catheter further than 30 or 35 mm from the proximal border of the carpal tunnel, probably because of tenosynovial hypertrophy, perineurial nerve fibrosis, or adherence between the nerve and the flexor tendons or between the nerve and the roof of the carpal tunnel. In these cases the first and the more distal pressure value recorded was at the level where the catheter could not penetrate any further.

No side effects to pressure measurement were reported by any of the subjects.

University of Modena, Departments of Orthopedics [1], Neurology [2], and Physics [3], Modena, Italy

Correspondence: Dr. Riccardo Luchetti, Ospedale di Stato, Divisione di Ortopedia, Traumatologia e Chirurgia della Mano, RSM 47031 Cailungo, Repubblica di San Marino

Table 1. Comparison of pressure values in 4 control subjects and 30 carpal tunnel syndrome patients

Millimeters from incision	Controls				Patients				
	Range	Mean	*SD*	n	Range	Mean	*SD*	n	*P*-value
10	4–17	10	*12*	3	4–35	12	*8*	20	NS
15	3–12	8	*9*	4	1–52	21	*15*	29	0.0002
20	5–16	12	*13*	4	9–66	27	*15*	30	0.0001
25	4–19	12	*15*	4	11–92	37	*18*	30	0.0000
30	5–24	15	*18*	4	7–88	44	*20*	30	0.0000
35	3–24	15	*18*	4	2–91	34	*20*	28	0.0002
40	3–29	15	*20*	4	2–66	24	*17*	26	0.0200
45	6–26	13	*19*	3	0–60	21	*16*	16	NS
50					2–36	13	*11*	7	

Results

The mean pressure in the normal control subjects was 13 mmHg and in the carpal tunnel syndrome patients 26 mmHg (Table I). In the normal subjects the pressures did not change along the canal, whereas in the patients the values in the middle section were 50 percent higher than the mean.

Discussion

The increased pressure within the carpal tunnel during wrist flexion and extension was measured in cadavers by Brain et al. (1947) with manometers. Tanzer (1959) made a similar study with a mercury bag in 6 carpal tunnel syndrome patients and in 6 cadavers. Neither study recorded absolute pressure, only movement-related pressure increases. Moreover, the devices used could have affected the pressure by their own volume (Gelberman et al. 1981).

Direct measurement of hydrostatic pressure is pertinent only when fluid or fluid-like compartments are involved. Because the carpal tunnel has proximal and distal openings, the pressure within it is not distributed as in a muscle compartment. An indirect method is more appropriate in the carpal tunnel where the interstitial pressure is evaluated by measuring hydrodynamic impedence of a constant infusion flow at the end of the catheter positioned within the tunnel. Flow is maintained to balance biological absorption in order not to affect pressure by itself. In this stationary state an increase in impedence causes a corresponding increase in hydrostatic pressure in the perfusion-fluid system, which can be easily recorded. This is the pressure reported in our study.

A higher pressure was found in the carpal tunnel syndrome patients than in controls as suggested by earlier reports. Moreover, the pressure was highest close to the middle segment of the carpal tunnel and decreased towards the borders. Our control pressures were slightly higher than those reported in the literature. However, no direct comparison can be made because of the methodologic differences.

Within muscle compartments an increase in pressure causes the compression of microvascular structures followed by progressive ischemia. At the risk pressure of about 30 mmHg (Lundborg et al. 1982), decreased extracellular exchanges begin to impair nourishment of all the surrounding structures. The neural tissue has been shown to be more resistant to injury from ischemia than muscle (Hargens et al. 1979), even if impaired nerve conduction can be demonstrated before abnormal muscle function is detectable (Sumner 1980).

The venous drainage of the rat sciatic nerve is impaired from a pressure of 30 mmHg on the nerve for 8 hours (Lundborg et al. 1983). In the carpal tunnel of volunteers, the first conduction abnormalities of the median nerve started after 90 min of compression at 30 mmHg (Lundborg et al. 1982).

From the present study, it is clear that this pressure of more than 30 mmHg is focally increased. In the carpal tunnel syndrome group, the average pressure was much higher than in the controls between 25 and 35 mm from the proximal border of the flexor retinaculum.

In 3 patients the maximum pressure did not reach the risk level of 30 mmHg, although they had typical symptoms. Perhaps these patients had abnormal "stress" pressures as suggested by Szabo and Chidgey (1988).

Focal damage to the median nerve within the carpal tunnel is suggested by computed tomography and magnetic resonance recording (Bleecker et al. 1985, Richman et al. 1987), which have shown that the dimensions of the carpal tunnel are not constant, explaining the pressure differences found in our study.

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Acknowledgement

The Hesperia Hospital, Modena, provided the equipment for the pressure measurements.