EVALUATION OF VARIOUS FIBRO-OSSEOUS TUNNEL PRESSURES (CARPAL, CUBITAL AND TARSAL) IN NORMAL HUMAN SUBJECTS

KUSH KUMAR, SANJAY DESHPANDE, MANOJ JAIN AND MADHAVA G. NAYAK

Department of Orthopaedics,
Mahatma Gandhi Institute of Medical Science,
Sevagram - 442 102, Wardha

(Received on December 16, 1987)

Summary : Intra carpal, cubital and tarsal tunnel pressures were measured with open bore needle technique in 170 normal subjects. The pressure in carpal tunnel with wrist in neutral position was between 2.75 to 4.46 mm Hg which increased to 20-30 mm Hg. during flexion and extension of wrist. Pressures recorded in cubital tunnel were 2-5 mm Hg with full extended elbow and rose to 10-15 mm Hg and 20-28 mm Hg during 90° flexion and full flexion of elbow respectively, pressures in tarsal tunnel were between 4-7 mm Hg in neutral position of ankle joint and with dorsi and plantar flexion of ankle it rose to 15-20 and 10-15 mm Hg respectively. There was no significant pressure difference between either sides and sexes; ages and proximally situated tunnel with distaly situated tunnel in same limb (Carpal tunnel Vs. Cubital tunnel). There was significant pressure difference between Carpal tunnel and Tarsal tunnel with wrist and ankle in their anatomical positions respectively.

Key words : cubital tunnel tarsal tunnel carpal tunnel tunnel pressure

INTRODUCTION

Compression of nerves passing through various fibro-osseous tunnels is well known (1). However not much work has been done to determine normal tunnel pressures. It is expected that the tunnel pressure should rise to an optimal level before signs and symptoms of nerve compression appear. Thus it becomes mandatory to determine normal pressures existing in various fibro-osseous tunnels. Three different types of tunnels were chosen for this study viz : cubital tunnel containing ulnar nerve, carpal tunnel having median nerve with long flexor tendons of hand and tarsal tunnel having post tibial vessels and nerve alongwith long flexor tendons of foot. Study was undertaken to determine the normal pressures in these different

Reprint Requests : Dr. Kush Kumar, C-7/159, Senpura, Chefganj - Ward, Varanasi - 221 001.

tunnels in different ages, sexes and different position of joints. Comparison of pressure difference was made between either sides, sexes, in upper and lower limbs and between proximaly placed tunnel with distally situated tunnel in same limb.

Though sporadic references are available where various workers have attempted to determine normal tunnel pressures in such fibro-osseous tunnels (2, 3, 4, 5) but to the best of our knowledge no work has been done in caucasians and specially in coloured races.

MATERIAL AND METHODS

Present study was conducted at Mahatma Gandhi Institute of Medical Sciences, Sevagram, Wardha, India, from June 1986 to January 1987. Open bore needle technique as described by Whiteside *et al.* (6), with slight modification was used in the present study, for evaluation of tunnel pressures. The apparatus was attached to a water manometer calibrated accurately to measures pressure upto 0-1 mm Hg, all pressures being expressed in mm Hg.

All recordings were obtained with the subjects in recumbent position. With all aseptic precautions, the needle of calibrated manometer was introduced into the carpal, cubital and tarsal tunnel, on both sides, one after another, to determine the tunnel pressures. Carpal tunnel pressures were measured with wrist in neutral, fully flexed and fully extended position. Cubital tunnel pressures were measured with full extension, 90° flexion and full flexion of elbow joint. Tarsal tunnel pressures were measured with neutral, full dorsi - and then planter flexion of ankle joint, where subjects actively moved the joints. No passive or forceful movement was attempted.

A total of 170 normal subjects were included in study out of which 100 were males and 70 females.

RESULTS

Observations were recorded and analysed according to age groups and sexes. Group A (<10 years) had 5 males and 4 females, Group B (10-20 yrs) had 14 males and 17 females, Group C (20-30 yrs) had 26 males and 19 females, Group D (30-40 yrs) had 16 males and 19 females Group E (40-50 yrs) had 13 males and 7 females, Group F (50-60 yrs) had 12 males and 8 females, Group G (60-70 yrs) had only 11 males and Group H (>70 yrs) had 3 males. Tunnel pressure and their analyses is given in Table No. I to III.

Statistically analysing the data using unpaired 't' test, significant pressure difference was found between carpal and tarsal tunnel pressures.

TABLE I : Carpal Tunnel pressure in mm Hg in Indian population.

Age in group of 10 yrs	*Neutral*		*90° Flexion*		*Extension*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*
Right side						
<10 yrs A	4.00 (±1.58)	3.00 (±0.82)	10.00 (±3.67)	14.50 (±1.73)	13.80 (±3.77)	17.00 (±6.70)
B	4.17 (±1.32)	4.38 (±1.90)	13.80 (±3.89)	15.91 (±5.98)	20.78 (±9.13)	20.23 (±6.93)
C	4.05 (±1.66)	2.26 (±1.81)	15.07 (±6.62)	16.55 (±7.64)	21.40 (±6.22)	23.00 (±6.20)
D	4.60 (±1.53)	4.53 (±0.99)	14.50 (±4.52)	19.93 (±4.57)	21.90 (±5.82)	25.60 (±6.20)
E	4.42 (±2.04)	4.57 (±2.22)	15.30 (±4.52)	13.42 (±3.26)	19.54 (±7.25)	14.14 (±4.67)
F	4.20 (±1.37)	4.13 (±1.36)	15.00 (±6.11)	18.00 (±6.23)	21.60 (±4.34)	23.13 (±6.29)
G	3.10 (±0.83)	—	13.50 (±6.14)	—	20.10 (±5.66)	—
>70 yrs H	4.50 (±1.50)	—	6.00 (±10.58)	—	16 00 (±6.43)	—
Left side						
<10 yrs A	4.00 (—)	3.00 (—)	15.00 (—)	14.00 (—)	17.00 (—)	19.00 (—)
B	3.24 (±0.73)	3.90 (±1.50)	12.78 (±4.17)	15.20 (±4.97)	24.02 (±5.63)	22.60 (±5.50)
C	3.60 (±1.24)	4.08 (±2.19)	14.15 (±5.65)	17.05 (±4.33)	21.96 (±5.41)	24.94 (±6.76)
D	3.59 (±1.81)	3.96 (±1.47)	13.80 (±6.34)	17.20 (±6.43)	20.00 (±5.14)	25.13 (±6.13)
E	3.77 (±1.99)	3.64 (±1.28)	15.46 (±6.77)	14.71 (±4.75)	19.31 (±5.95)	23.00 (±6.32)
F	4.12 (±2.17)	2.57 (±0.92)	15.08 (±6.17)	16.38 (±3.42)	22.50 (±5.04)	22.88 (±1 90)
G	3.86 (±1.52)	—	10.72 (±5.61)	—	19.27 (±5.14)	—
>70 yrs H	4.50 (±2.57)	—	16.50 (±12.77)	—	20.50 (±10.08)	—

Numbers in parenthesis designate S. D.

TABLE II : Cubital Tunnal pressure in mm Hg in Indian population.

Age in group of 10 yrs	*Neutral*		*90° Flexion*		*Extension*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*
Right side						
<10 yrs A	5.20 (±3.00)	4.25 (±1.90)	10.20 (±3.35)	11.50 (±4.12)	18.40 (±6.11)	19.50 (±8.70)
B	3.21 (±1.33)	3.30 (±1.50)	12.30 (±4.70)	13.30 (±5.60)	27.50 (±9.03)	22.70 (±7.33)
C	3.71 (±1.78)	3.24 (±0.96)	12.70 (±4.47)	16.11 (±5.76)	27.03 (±7.73)	26.74 (±7.49)
D	3.06 (±0.70)	3.13 (±1.88)	14.20 (±6.00)	18.60 (±6.17)	27.56 (±8.06)	27.87 (±6.14)
E	3.50 (±1.17)	3.10 (±0.93)	11.50 (±5.39)	10.42 (±5.19)	23.00 (±10.63)	23.43 (±5.53)
F	3.50 (±1.29)	3.38 (±0.79)	14.83 (±6.09)	16.13 (±5.28)	24.91 (±11.24)	26.38 (±8.52)
G	4.45 (±2.72)	—	14.45 (±6.27)	—	23.09 (±8.26)	—
>70 yrs H	4.50 (±1.73)	—	11.50 (±6.11)	—	17.00 (±9.01)	—
Left side						
<10 yrs A	4.00 (—)	2.00 (—)	15.00 (—)	13.00 (—)	20.00 (—)	16.00 (—)
B	3.60 (±1.93)	2.80 (±0.96)	14.20 (±5.92)	11.80 (±3.59)	24.20 (±8.61)	22.50 (±5.20)
C	3.59 (±1.77)	3.50 (±1.29)	12.63 (±3.91)	13.57 (±4.57)	25.77 (±7.97)	24.26 (±5.91)
D	3.13 (±1.20)	3.43 (±1.39)	12.40 (±4.13)	15.30 (±4.84)	25.86 (±5.84)	24.93 (±6.97)
E	3.23 (±2.22)	3.64 (±0.75)	11.12 (±4.88)	10.50 (±6.88)	21.50 (±9.93)	23.71 (±7.31)
F	3.58 (±1.04)	2.43 (±1.30)	12.17 (±4.86)	15.29 (±2.49)	23.25 (±9.42)	26.43 (±8.46)
G	2.90 (±1.07)	—	11.31 (±6.33)	—	20.00 (±11.20)	—
>70 yrs H	4.00 (±1.16)	—	10.25 (±4.77)	—	17.00 (±10.06)	—

TABLE III : Tarsal Tunnel pressure in mm Hg in Indian population.

Age in group of 10 yrs	*Neutral*		*90° Flexion*		*Extension*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*
Right side						
<10 yrs A	4.30 (±1.10)	4.50 (±1.73)	12.60 (±3.39)	12.50 (±3.32)	12,80 (±1.30)	15.00 (±8.72)
B	5.09 (±1.01)	5.12 (±1.26)	17.05 (±4.40)	16.53 (±5.19)	12.45 (±4.46)	14.50 (±3.76)
C	4.96 (±1.51)	5.47 (±1.54)	17.34 (±3.40)	16.05 (±5.44)	14.34 (±6.69)	13.16 (±3.47)
D	5.50 (±1.22)	4.96 (±1.25)	17.42 (±7.49)	17.26 (±4.79)	16.35 (±5.89)	14.40 (±4.75)
E	6.00 (±2.14)	5.35 (±2.13)	18.55 (±7.48)	11.30 (±4.46)	17.82 (±6.46)	11.28 (±5.31)
F	5.37 (±1.03)	5.43 (±1.42)	18.58 (±5.87)	15.62 (±4.50)	18.33 (±7.08)	14.25 (±3.45)
G	5.40 (±0.84)	—	16.30 (±5.95)	—	13.50 (±4.74)	—
>70 yrs H	5.50 (±2.57)	—	14.50 (±4.04)	—	6.50 (±6.24)	—
Left side						
<10 yrs A	4.00 (—)	4.00 (—)	16.00 (—)	16.00 (—)	16 00 (—)	9.00 (—)
B	4.48 (±1.88)	5.53 (±1.15)	16.07 (±6.24)	15.00 (±4.62)	13.00 (±5.70)	14.10 (±4.38)
C	4.48 (±2.07)	5.55 (±1.94)	15.11 (±6.35)	15.10 (±4.75)	14.38 (±8.02)	12.31 (±3.62)
D	5.57 (±1.14)	5.46 (±1.20)	14.82 (±6.01)	15.80 (±4.02)	15.96 (±4.46)	13.30 (±3.56)
E	5.70 (±1.69)	4.79 (±1.48)	18.40 (±6.87)	11.86 (±7.31)	11.40 (±4.48)	9.71 (±3.90)
F	5.08 (±1.10)	4.79 (±1.22)	17.54 (±5.50)	16.57 (±3 31)	15.50 (±4.64)	13.29 (±3.77)
G	5.00 (±1.62)	—	16.00 (±5.44)	—	16.20 (±7.99)	—
>70 yrs H	5.50 (±0.76)	—	12.00 (±6.66)	—	4.50 (±6.08)	—

Tarsal tunnel pressure is higher than carpal tunnel pressure in anatomical positions. But no significant difference ($P>.0001$) was noted between cubital and carpal tunnel pressure of the same side in anatomical position.

DISCUSSION

Involvement of peripheral nerves due to machanical compression in narrow anatomical tunnels is well known. A common feature of various tunnel syndromes is increase in the volume of the contents of the tunnel resulting into the increase in intratunnel pressure in direct proportion.

Review of available English literature could not reveal much information about pressure measurements of the fibro-osseous tunnels in normal human beings and in those suffering from various tunnel syndromes. Though attempts have been made in the past to determine tunnel pressure, authentic reports are very few (2, 3, 4, 5). To the best of our knowledge no work is available in Caucasions or in coloured races.

There can be several methods of recording the tunnel pressure like with the help of pressure transducer on a polygraph or with 'Wick catheter technique' as described by Mubarak and Hargens. But in the present study "Open bone needle technique" as described by Whiteside *et al.* (6) with slight modification has been used. The equipment was not only economical but could easily be transported. However "Open bore needle technique" may not be as accurate as other methods mentioned above giving about 1 to 2 mm of Hg higher recordings. It is because of that fact that some fluid is to be injected to get free flow of fluid at the orifice of the needle to get the nonequilibrium condition. As it does not make much difference this method was adopted.

Gelberman (2) was prohably the first to have successfully recorded the pressures in patients suffering from carpal tunnel syndrome. His sample size was however very small and is really difficult to accept the work as standard. Werner (5) also used the "Wick catheter technique" with transducer recording assembly but worked again on carpal tunnel only.

In the present study, mean carpal tunnel pressure with wrist in neutral position in various age groups were ranging between 2.75 to 4 46 mm Hg. Flexion and extension of the wrist lead to increase of pressure ranging between 20 to 30 mm Hg. Tanzer (3) also noted an increase in pressure in carpal tunnel with wrist flexion and extention but he arbitrarily considered carpal tunnel pressure in neutral position of the wrist to be zero. Gelberman (2) noted pressure in carpal tunnel in neutral position of the wrist as 2.5 mm Hg with increase in

flexion and extension to 30 mm Hg. In case of carpal tunnel syndrome, Gelberman *et al.* (2) and Werner (5) noted pressure upto 90 mm Hg.

Cubital tunnel pressure in the present study was found to be ranging between 2 to 5 mm Hg which increased after flexion of the elbow upto 28 to 30 mm Hg. Werner (5) also got range between 0 to 19 mm Hg and noted increase in pressure with flexion of elbow.

Tarsal tunnel pressure in the present study was recorded between 4 to 6 mm Hg in neutral position of the ankle which increased to 10 to 15 mm Hg during plantar flexion and 10 to 20 mm Hg during dorsi flexion of the ankle joint. As no similar study on tarsal tunnel pressure is available the results could not be compared with other workers. Alteration in pressure due to standing walking and after exercises has not been studied.

Such a study might help in selecting cases for prophylactic decompressive surgery. Those patients where tunnel pressures are normal and having some symptoms can be treated conservatively whereas those in which pressure recordings are abnormally high without any apparent nerve damage should be treated surgically to avoid permanent damage to the nerve later on.

ACKNOWLEDGEMENTS

Authors are grateful to Dr. M. C. Gupta, Associate Professor and Dr. (Mrs.) Vibha Kumar, Lecturer, Department of Community Medicine for helping in statistically analysing the data.

REFERENCES

1. Brain, W. R., A. D. Wright and M. Wilkinson. Spontaneous Compression of both median nerves in the carpal tunnel, six cases treated surgically. *Lancet*, **1** : 277-282, 1947.
2. Gelberman, R., T. Patrick, Alan R. Hargenroeder, Goran N. Hargens, Lundborg and H. Akeson Wayne. "The carpal tunnel Syndrome" *J. Bone and Joint Surg.*, **63-A** : 380-383, 1981.
3. Tanzer, R. C. The Carpal tunnel syndrome. A Clinical and Anatomical Study. *J. Bone and Joint Surg.*, **41-A** : 626-634, 1959.
4. Werner, C. O., D. Elmquist and P. Ohlin. Pressure and nerve lesion in the Carpal tunnel *Acta Orthop. Scand.*, **54** : 512, 1983.
5. Werner, C. O., Per Ohlin and Dam Elmquist. Pressure recorded in ulnar neuropathy. *Acta Orthop. Scand.*, **56** : 404-406, 1985.
6. Whiteside, T. E., T. C. Haney, H. Harda, H. E. Holmes and K. Morimoto. A simple method of tissue pressure determination. *Arch. Surgery*, **110** : 1311-1314, 1975.