Comparison of the Mean Cross-sectional Area of the Median Nerve between Pregnant and Non-Pregnant Women Using Ultrasonography in a Tertiary Level Hospital, Nepal

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Citation

Adhikari G, Regmi PR, Paudel S, Lamichhane B, Kayastha P, Maharjan S, et al. Comparison of the Mean Cross-sectional Area of the Median Nerve between Pregnant and Non-Pregnant Women Using Ultrasonography in a Tertiary Level Hospital, Nepal. *Kathmandu Univ Med J.* 2023;81(1):69-73.

ABSTRACT

Background

The median nerve is subjected to compression in the carpal tunnel giving rise to a constellation of symptoms known as carpal tunnel syndrome. It is the most frequent form of peripheral entrapment neuropathies and is most prevalent in the middle age females. The most common cause of this syndrome is idiopathic. One of the known secondary causes is pregnancy.

Objective

To compare the mean cross sectional area of median nerve using ultrasound in pregnant and non-pregnant females at carpal tunnel inlet and its variations with different trimesters.

Method

The study was conducted during a period of one year (October 2014 to September 2015). A total of 204 participants were evaluated among which 102 were nonpregnant and 102 were pregnant. Among the 102 pregnant participants, 34 females each were in the first, second, and third trimesters. A convenience sampling technique was used for the selection of the participants. The mean cross-sectional area of the median nerve was calculated in both of these groups in both hands by using the direct method. The mean cross-sectional area of non-pregnant female was used as the reference value to which that of pregnant female were compared. Data obtained were compiled and analyzed using Statistical Package for Social Sciences Version 16.

Result

The overall mean cross-sectional area of the median nerve in non-pregnant females was 6.76 ± 1.05 mm^2 and in pregnant females was 6.84 ± 1.09 mm. No statistically significant difference was noted in the mean cross-sectional area of the median nerve in either hand in both pregnant and non-pregnant females. No statistically significant difference was noted in the overall mean cross-sectional area between the non-pregnant and pregnant females. There was no significant difference in the mean cross-sectional area within the different trimesters in both hands on intergroup comparisons.

Conclusion

Ultrasound examination of the median nerve and measurement of its cross-sectional area is a useful diagnostic tool in the evaluation of carpal tunnel syndrome. Ultrasound has the advantage of easy availability, low cost, quick scan time, able to scan a long segment of nerve and examine the structures in both static and dynamic states. Besides, it also helps in the identification of various anatomic variants and pathologies within or adjacent to carpal tunnel.

KEY WORDS

Carpal tunnel, Mean cross sectional area, Median nerve, Ultrasonography

INTRODUCTION

The median nerve is an important structure, the distal segment of which is located within the carpal tunnel at the wrist. It is subjected to compression in the carpal tunnel giving rise to a constellation of symptoms known as carpal tunnel syndrome (CTS). CTS is the most frequent form of peripheral entrapment neuropathies and is most prevalent in the middle age females. The most common cause of this syndrome is idiopathic.[1-3] The secondary causes are pregnancy, rheumatoid arthritis, acromegaly, oral contraceptive pill usage, collagen vascular disease, multiple myeloma, amyloidosis, diabetes mellitus, sarcoidosis, mass lesions, tenosynovitis, past history of trauma and surgery at the wrist.[4]

Symptoms of CTS include paresthesia (numbness, tingling, and burning) in the median nerve distribution (first 3rd digits and radial half of 4th digit) along with deep aching pain in the hand and wrist.[5] These symptoms are intermittent and typically worse at night where the patient is awakened from sleep and relieves the discomfort by vigorously shaking the hand (Flick sign).[6]

The symptoms are due to raised pressure in the carpal tunnel causing compression of the segment of the median nerve running through the tunnel.[7] CTS affects approximately 8% of the population worldwide. Recent advances in ultrasound (US) transducer technology have led to the development of very high-frequency probes that allow the imaging of superficial structures with exquisite detail. The fine spatial resolution, speed of examination, and dynamic assessment make sonography useful for musculoskeletal examination including peripheral tendons and nerves.[8] Various parameters have been described regarding the use of US for the diagnosis of CTS of which the cross-sectional area (CSA) at the entrance of the carpal tunnel seems to have the highest diagnostic sensitivity and specificity.[2,9,10]

The pathophysiology of pregnancy-related carpal tunnel syndrome (PRCTS) has been mostly attributed to redistribution of fluids.[11-13] Hormonal changes, tenosynovitis, vulnerability of the peripheral nerves, maternal age, weight gain, parity, smoking, and alcohol are factors reported to be related to CTS in pregnancy.[13-19] Pregnancy is a natural and physiological phenomenon and is considered one of the secondary causes of CTS. Various studies have demonstrated the usefulness of the US in the evaluation of CTS with an increase in CSA of the median nerve within the carpal tunnel as the most reliable parameter. The CSA of the median nerve in pregnant females without symptoms and signs of CTS has not been evaluated till date to our knowledge. The purpose of this study is to measure the mean CSA of the median nerve at the carpal tunnel inlet in asymptomatic pregnant females of different gestational ages and compare the measured values with the age-matched asymptomatic non-pregnant females.

METHODS

Pregnant females (20-40 years) who were referred for the obstetric ultrasound in different trimesters as a part of the routine obstetric examination and non-pregnant females (20-40 years) who were referred for the abdominal ultrasound for various conditions to the ultrasound unit of the Department of Radiology and Imaging in Tribhuvan University Teaching Hospital from October 2014 to September 2015 were included in the study. Approval of ethical clearance was obtained from the Institutional Review Board (IRB), Institute of Medicine (IOM). There were a total of 204 study participants. Among them, 102 were pregnant females and 102 were non-pregnant females and were selected conveniently for the study. Pregnant females were divided into first, second, and third trimesters with 34 participants in each trimester. The participants with a past history of trauma or surgery in the wrist, history of other secondary causes of carpal tunnel syndrome, positive clinical examination including Tinel's and Phalen's test, and with anatomic variants like high division of the median nerve, bifid median nerve, accessory tendons or muscles were excluded from the study. Written informed consent forms were taken from all the participants and no active intervention was done in any participants.

The cross-sectional area of the bilateral median nerve at the carpal tunnel inlet was measured in both of these groups who met the inclusion criteria by using a high-frequency linear array transducer (L17-5) of a Phillips-iU-22 ultrasound machine. For the measurement of the median nerve at the wrist from the direct method, the protocol of the examination was as follows: 1. The wrist was placed, palm upward, on a flat surface; 2. The transducer was positioned perpendicular to the median nerve, with no pressure on the skin to avoid deformation of the nerve; 3. Axial images were obtained at the level of the pisiform bone, and the image with the optimal definition of the borders of the median nerve was selected; and 4. Median nerve CSA measurements were performed from the inner border of the perineural echogenic rim, corresponding to the perineurium around the hypoechoic median nerve.[2]

The overall mean CSA for both groups was calculated by adding the values from the right and left hands. A comparison of the overall mean CSA was done between the pregnant and non-pregnant groups. A comparison of the mean CSA of the first, second, and third trimester females was also done with the mean CSA of the non-pregnant females. Intergroup comparison of the mean CSA of the first, second, and third trimesters was also done.

Data obtained was entered in Microsoft Excel and analysis was done by using SPSS version 16. Paired t-test was used for comparing differences between non-pregnant and pregnant groups. One way ANOVA test was used to compare the mean cross-sectional area between the different trimesters in pregnant females. Pearson's

correlation was used to find out the correlation of mean cross-sectional area in different trimesters. A P-value < 0.05 was considered statistically significant.

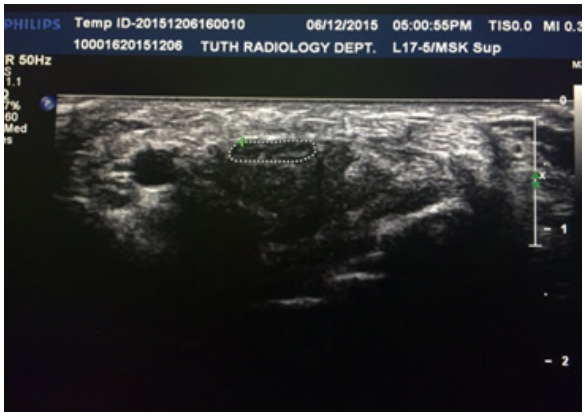

Figure 1. Direct or tracing method for measurement of cross sectional area

RESULTS

A total of 204 participants were evaluated who met the selection criteria. Among them, 102 were non-pregnant, and the remaining 102 were pregnant females. Among the pregnant females, 34 each were in the first, second, and third trimesters. In the non-pregnant group, the maximum number of participants was in the age group 20-24 years (N = 51, 50%). Similarly, in the pregnant group, the maximum number of participants were in the age group 20-24 years (N = 43, 42.1%) (Fig. 2). Mean age of non-pregnant females was 25.53 ± 3.92 years, and of pregnant females was 25.97 ± 4.18 years. The age range of non-pregnant females was 20-38 years and of pregnant females was 20-36 years.

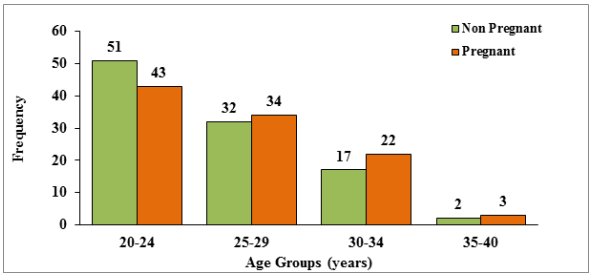

Figure 2. Age distribution of pregnant and non-pregnant females

The overall mean cross-sectional area of the median nerve (calculated by adding the values of both hands) in non-pregnant females was 6.76 ± 1.05 mm^2. In the pregnant females, the overall mean cross-sectional area was 6.84 ± 1.09 mm^2. The minimum and maximum CSA in non-pregnant females was 5.1 mm^2 and 11.3 mm^2.

In pregnant females, the minimum and maximum CSA were 4.65 mm^2 and 11.4 mm^2. There was no statistically significant difference in the overall mean CSA of the median nerve in non-pregnant and pregnant females.

In pregnant females, the mean CSA was 6.84 ± 1.19 mm^2 and 6.83 ± 1.19 mm^2 in right and left hands respectively. The maximum values of CSA in the right and left hand were 11.2 mm^2 and 11.7 mm^2 respectively. Similarly, the minimum values of CSA in the right and left hand were 4.7 mm^2 and 4.4 mm^2 respectively. No statistically significant difference was seen in the mean CSA of the right and left hands (p = 0.925). In the first trimester females, the mean CSA of the median nerve was 6.67 ± 1.24 mm^2 and 6.50 ± 0.88 mm^2 in the right and left hand respectively. In second-trimester females, the mean CSA of the median nerve was 6.82 ± 1.29 mm^2 and 6.88 ± 1.32 mm^2 in the right and left hand respectively. In third-trimester females, the mean CSA of the median nerve was 7.04 ± 1.04 mm^2 and 7.12 ± 1.27 mm^2 in the right and left hand respectively. No statistically significant difference was noted in the CSA of the median nerve in either hand in non-pregnant versus pregnant females. By using one way ANOVA test, there was no statistically significant difference in the mean CSA of the median nerve within the different trimesters in both hands (Table 1). Similarly, no significant correlation of the mean CSA was noted between the different trimesters in pregnant females (p = 0.063, r = 0.185).

Table 1. Intergroup comparison of the mean CSA of the median nerve in pregnant females in first, second and third trimesters

	Mean CSA (mm^2), Trimester			
Hand	**First**	**Second**	**Third**	**p-value**
Right	6.67	6.82	7.04	0.444
Left	6.50	6.88	7.12	0.097

DISCUSSION

Median nerve is the most commonly affected nerve in peripheral entrapment neuropathies which occurs within the carpal tunnel giving rise to a constellation of symptoms known as carpal tunnel syndrome. The diagnosis of this condition is usually done based on clinical symptoms and various physical examinations and is confirmed by a nerve conduction study which is the most reliable diagnostic tool.10 Besides the idiopathic cause, which is the most common, many secondary causes are known which is responsible for CTS. The role of ultrasound imaging lies in the assessment of these conditions which are responsible for elevating the pressure within the carpal tunnel. Congenital anomalies include an aberrant flexor muscle of the index finger and a persistent median artery of the forearm. Acquired disease can lead to increased content of the tunnel, as in tenosynovitis of flexor tendons, ganglion cyst, lipoma, vascular tumors, or amyloid deposits.[20-23] Ultrasound can also help to differentiate tenosynovitis of flexor tendons from other space-occupying lesions in the tunnel and helps assess postsurgical complications.

US criteria for median nerve compression include the classic triad of nerve flattening in the distal tunnel, nerve swelling at the distal radius or (less frequently) in the proximal tunnel, and palmar bowing of the flexor retinaculum. However,

the cross-sectional area (CSA) at the entrance of the carpal tunnel seems to have the highest diagnostic sensitivity and specificity.[2,9,10] A good correlation has been demonstrated between the area of the median nerve measured with the US and the severity of electromyographic findings or the functional outcome after surgery.[4]

The cross-sectional area of the median nerve was calculated by direct method. Only the hypoechoic nerve was measured excluding the outer echogenic perineurium. The overall mean CSA of the median nerve in non-pregnant females was 6.76 ± 1.05 mm^2 and in pregnant females was 6.84 ± 1.09 mm^2. The overall mean CSA in non-pregnant females calculated in the present study was similar to the study done by Wanitwattanarumlug et al. in the Thai population (mean CSA= 6.83 ± 0.98 mm^2 by direct method).[26] Similarly, the findings of the mean CSA of the non-pregnant group of our study also match that of the study done by Akcar et al. and Ajeena et al. (mean CSA= 6.87 ± 1.04 mm^2).[27,28] The mean CSA of the non-pregnant females calculated in our study was lower than that calculated by Mani et al. where the mean CSA in the asymptomatic population was 7.4 ± 1.1 mm^2.[29] The lower value obtained in the non-pregnant group in our study may be because only female participants were included in this study to match the pregnant group and Andrea et al. recoded that CSA of the median nerve proximal to the carpal tunnel was greater in men than in women by 2.2 mm^2.[30] Also the difference in the values may be due to the different race and body habitus of the population under study. There was no significant difference in the mean CSA of the median nerve in either hand in both pregnant and non-pregnant females. These finding were in agreement with the study done by Wanitwattanarumlug et al. where they found no significant difference in the mean CSA between the right and left hand.[26]

Regarding the mean CSA in asymptomatic pregnant females, no studies have been done till date as per our knowledge on the literature review. In literature, it has been stated that the incidence of PRCTS is variable and ranges from 0.34% by Stolp-Smith et al. to 62% by Padua et al. depending on the study design and the criteria for diagnosis.[13,30] Up to 62% of pregnant women reported hand symptoms in the third trimester.[13] However, in this study during the evaluation of 102 pregnant females, none of the participants had hand symptoms attributable to CTS. This finding was in contradiction to the study done by Padua et al.[13] This may be due to the small number of third-trimester females (N = 34) in the present study population. Larger studies are required to calculate the incidence of PRCTS in the third trimester.

CONCLUSION

Ultrasound examination of the median nerve and measurement of its CSA is a useful diagnostic tool in the evaluation of CTS. Ultrasound has the advantage of easy availability, low cost, quick scan time, able to scan a long segment of nerve and examine the structures in both static and dynamic states. Besides, it also helps in the identification of various anatomic variants and pathologies within or adjacent to carpal tunnel. It should be emphasized that standardization of the sonographic technique is essential to achieve diagnostic reliability.

Normal mean CSA of asymptomatic pregnant and non-pregnant females has been established by this study in our setup. The non-pregnant and pregnant group consists of fewer participants, which may not represent the entire population and can be the limitation of this study. However, the data obtained from the present study can still be used as a reference until large studies are conducted and the standard normal ranges are established in our population.

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