Burst TENS: An Immediate Alternative Therapy to Reduce Systolic Blood Pressure Temporarily in Hypertensives.

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Abstract- Hypertension is a major risk factor for cardiovascular morbidity and mortality. It is paramount that the resting blood pressure is within normal limits for safe prescription of exercise. Burst TENS on peripheral vascular resistance implies a sympathetic inhibition which results in peripheral vasodilatation which results in lower blood pressure. Sixty patients of either gender of 30-65 years diagnosed as essential hypertension were recruited for the study. The patients in experimental group received Burst TENS and in control group received Sham TENS for 30 minutes. Pre - post blood pressure measurements were noted inboth the groups and compared for statistical significance. The exercise blood pressure response to six minute walk test was studied with and without TENS. A statistically significant reduction ($p<0.05$) was obtained in Systolic, Diastolic blood pressure and in Mean arterial pressure in the experimental group while there was no significant change in the control group for both immediate as well as the exercise response. Thus the immediate effect of Burst TENS shows a significant reduction in Blood Pressure in hypertensive individuals and can be safely used adjunct to drug therapy to lower the abnormal exaggerated blood pressure response to exercise in hypertensive patients.

Index Terms- Burst TENS, Exercise, Hypertensive, Six minute walk test

I. Introduction

Hypertension is well documented as a major risk factor for cardiovascular morbidity and mortality. It is an important public health challenge in both economically developed and developing countries.[1] For every 20 mmHg systolic or 10 mmHg diastolic increase in BP, the mortality is doubled for both ischemic heart disease and stroke.[2] A 2mm Hg lowering of systolic BP reduces death from stroke by 6% and heart disease by 4%. According to the VII Joint National Committee guidelines for hypertension, lifestyle modifications such as exercise, weight loss and salt and dietary restriction play important role in blood pressure management. A single session of dynamic exercise can evoke an exaggerated hypertensive response and may be accompanied by some limitation in exercise tolerance in certain hypertensive subjects. The Framingham Heart Study reported that patients with an exaggerated blood pressure response had a 10% greater left ventricular mass than those who did not [3], hence the response to exercise in hypertensive patients may be a more useful end point to assess the efficacy of antihypertensive therapy than is resting blood pressure.

For safe prescription of exercise it is important that resting blood pressure is within normal limits. Less widely prescribed but increasingly popular is the complementary and alternative medicine antihypertensive therapies. The current modality Transcutaneous Electrical Nerve Stimulation (TENS) is primarily used for pain relief [4]. Studies of effect of Burst TENS on peripheral vascular resistance imply a sympathetic inhibition which causes peripheral vasodilatation and thus increase blood flow and lower blood pressure[5]. Jacobson et al suggested that TENS may have additional blood pressure lowering properties in hypertensive patients who do not respond properly to pharmacological treatment[6]. The effect of TENS on blood pressure is a field of growing interest. Our study aimed at evaluating the immediate effect of TENS on resting BP and exercise BP in hypertensive individuals.

II. METHODOLOGY:

It was a prospective randomized controlled intervention approved by institutional ethics committee of tertiary care hospital. Sixty patients of either gender in the age group of 30-65 years diagnosed as essential hypertension were recruited. Patients with autoimmune, hormonal, neurological respiratory, cardiovascular disorders or with secondary hypertension were excluded from the study. Patients unable to understand, psychologically disturbed and having difficulty in walking or any musculoskeletal disorder which would interfere with ambulation were also excluded. Patients were randomly allocated via lottery method into experimental or control group. The patients in experimental group received Burst TENS and in Control group received Sham TENS.

In order to study immediate short term effect, heart rate and blood pressure was recorded, pre and post Burst TENS and Sham TENS application in experimental and control group respectively. The next day at the same time, to study exercise related BP response, Six minute walk test (6MWT) was used as an exercise stressor. It was performed according to ATS guidelines 2002 with standardized instructions. Blood pressure change with 6MWT was recorded with and without Burst TENS or Sham TENS application as assigned upto 30 mins of recovery following 6MWT.

Baseline paramaters were recorded with patient sitting comfortably on chair with arm rest for ten minutes and with feet supported. They were advised not to drink coffee or smoke cigarette thirty minutes before having their blood pressure measurement. At the first assessment BP was measured on both arms to check any variance between the arms. The possibility of raised BP in response to the assessment itself (white coat hypertension) was considered and ruled out. Two reading were taken at least 2 min apart and average was found.

Burst TENS was applied to experimental group for 30 minutes with the patient positioned comfortably on a chair with arms supported on table. The Burst TENS frequency of 2/100 Hz was used, with pulse duration of 0.2ms; mild perceptible intensity ranging from 2-20 mA. Carbon electrodes were fixed at two acupuncture points: - LI 4 and LI 11 (Figure1).

LI 4- Hegu point- It is on the dorsum of the hand, between the first and second metacarpal bones on the radial side of the midpoint of the second metacarpal bone. LI 11- Quchi point- Located in the elbow in the depression at the lateral end of the transverse cubital crease and the lateral epicondyle of the humerus.

Sham TENS was applied in the similar manner. The battery was designed to show the flickering of light with no output for Sham TENS. The participants were informed that there may be no perception of current. Participants could see the output light flashing but no current was transmitted to the acupoint throughout the 30 minutes.

III. Results:

Data was analyzed using SPSS 16 with a 'p' value < 0.05 for statistically significant. Data was normally distributed. Total 96 patients were screened and 60 included as per selection criteria and randomly allocated in each group. Both the groups were comparable for baseline characteristics of age, Body mass index, systolic and diastolic blood pressure and pulse rate. By applying student's unpaired 't' test it was seen that there is no significant difference between baseline mean values of Burst TENS group and Sham TENS group. Paired t test was used for within group comparison and unpaired t test was used for inter group comparison.

In Experimental group (Table 1) an immediate reduction of SBP was observed from mean 140.80 to 130.13 mmHg, (reduction by10.67mm Hg)which was statistically significant [$p<0.05$]. A statistically significant reduction was obtained in DBP reduction from mean 92.13 to 83.47 mmHg and in mean arterial pressure from 108.36 to 99.02 mmHg. In control group there was no significant change in SBP or DBP from the baseline values.

On comparing the mean change in BP paramaters (Table 2) there was a clinically and statistically significant reduction in blood pressure parameters in Burst TENS group compared to Sham TENS.

Paired 't' test was used to compare the change in blood pressure parameters following 6 MWT Before and after Burst TENS (Table3) in experimental group and control group. There was a statistically significant ($p<0.05$) reduction in exercise blood pressure response to 6MWT in Burst TENS after application, however there was no statistically significant ($p>0.05$) difference obtained in control group. On comparing the mean change in paramaters between both the groups there was a statistically significant difference in the exercise blood pressure response. The control group showed a greater rise in BP compared to experimental group (Table4) . The pressures were observed to remain elevated even after 30 mins of recovery in control TENS group. Unpaired 't' test was applied to compare parameters post 30 minutes recovery time following 6 MWT after burst TENS and Sham TENS application. Significant reduction in parameters was found in Burst TENS group as compared to Sham TENS group ($p<0.05$)

IV. Discussion:

Hypertension is a major risk factor for coronary artery disease and stroke, which are highest causes of mortality[7,8]. Blood pressure changes during exercise and recovery period are analogous with blood pressure responsiveness to daily physical stress conditions. The aim of the present study was to find the short term effect of Burst TENS at rest and on post exercise blood pressure in hypertensive subjects In the present study 60 hypertensive subjects were randomly divided into Burst TENS(experimental) and Sham TENS (control) group. The control group was given sham TENS in order to take care of psychological aspect of application of treatment with device and effect of rest if any.

The results of this study showed that there was a clinically and statistically significant reduction in parameters ($p<0.05$) after application of Burst TENS (experimental group) whereas there was no significant reduction in parameters ($p>0.05$) in Sham TENS (control group). A 2mm Hg lowering of systolic BP reduces death from stroke by 6% and heart disease by 4%, in our study we obtained a mean reduction of 10.67 mm Hg in SBP and 8.67 mm Hg in DBP.

The anticipation of exercise activates the sympathetic nervous system. As exercise begins there is further increase in sympathetic tone, reduction in vagal tone and increased circulating catecholamine levels. This leads to proportionate increase in heart rate and systolic blood pressure whereas the diastolic blood pressure remains unchanged or decreases as a result of vasodilatation and decreasing total peripheral resistance in normal persons[9] . An exaggerated increase in systolic blood pressure at submaximal exercise increased mortality in hypertensive patients. The relative risk for death from cardiovascular disease increased with the elevation in systolic blood pressure during exercise[10,11].

The end-organ effects of hypertension are progressive, and resting blood pressure may not accurately indicate the underlying state of the disease.Blood Pressure response to 6MWT (a submaximal test) demonstrated a typical exercise stressor response.In experimental group after Burst TENS application it showed a statistically significant reduction in both systolic and diastolic blood pressure increase as compared to Sham TENS. The mean rise obtained in Burst TENS group following 6 MWT for SBP was 23.67 mmHg and DBP was mean 1.27mmHg compared to 35.67mmHg, DBP was mean 10.07 mmHg in sham TENS group. Thus it is seen that the abnormal elevation in blood pressure following exercise is prevented due to application of Burst TENS. Hence the complication and risks arising due to exaggerated blood pressure response are prevented.

Also the blood pressure remained maintained post 30 minutes following 6 MWT after burst TENS application in experimental group. The results showed that there was significant difference 30 mins of 6 MWT in experimental group as compared to control group (p<0.05) after Burst TENS the SBP mean was 130.13mmHg, DBP mean was 83.47 mmHg, where as in control group the SBP mean was141.33 mmHg, DBP mean was 91.93 mmHg. This carry over effect of Burst TENS has a great clinical value since it aids in the safe prescription of exercise and helps prevents any cardiovascular injury during and post exercise.

In the early phases of hypertension, calculated total peripheral resistance is normal at rest but does not decrease during exercise because of a reduced vasodilatory capacity. When fixed hypertension develops, peripheral resistance increases.These responses of peripheral vascular function can be explained by a hyper-reactivity of sympathetic nerves and an increased vascular response to adrenergic stimulation or by a thickening of the arteriolar wall that alters its ability to respond to vasoconstrictor stimuli[12].

For decades, acupuncture and electro needling treatments have been used, predominately in the Eastern countries, in the management of patients with compromised cardiovascular and digestive functions. Similarly, neuromuscular electrical stimulation is commonly employed in Western countries to modulate pain, augment muscle strength and enhance blood flow in patients with peripheral vascular disease. Many rehabilitation specialists believe that electrical stimulation of acupuncture points with surface electrodes can elicit the same physiological and therapeutic effects as those produced by acupuncture and electro needling techniques. Electrical stimulation of acupuncture points with surface electrodes is a relatively new and non-invasive treatment with potential clinical application in the management of patients with vascular disease.

Acupuncture treatments using low levels of electrical stimulation can lower elevations in blood pressure by as much as 50 percent, researchers at the Susan Samueli Center for Integrative Medicine at UC Irvine have found. Overall, the researchers found that a 30-minute treatment reduced blood pressure rates in these test rats by 25 mmHg - with the effect lasting almost two hours. Acupuncture is invasive and therefore carries some risk of injury.Application of transcutaneous electrical nerve stimulation, a non-invasive modality, over specific acupoints (Acu-TENS) is believed to elicit similar responses to manual acupuncture in pain relief.

Transcutaneous electrical nerve stimulation (TENS) is typically used for alteration of pain perception. Several investigators, however, have reported that TENS can affect the peripheral vascular system5 . Burst-mode TENS stimulates peripheral nerve fibers using relatively high carrier frequencies (80–100 pps), modulated burst frequencies (2–5 bps), and intensities above or below the motor threshold5 . This pattern of external stimulation more closely mimics physiologic sympathetic nerve activity than continuous-mode high- or low-frequency stimulation does[5] .

TENS produces a reduction in BP which may be associated with vasodilatation. They suggested that an opioid-serotonergic mechanism or VIP (vasoactive intestinal polypeptide) as possible neurotransmitters involved in TENS induced vasodilatation[13] .

The reduction in blood pressure due to burst TENS may be caused by the central inhibition of the sympathetic activity14 . In rats, the post stimulatory inhibition of sympathetic activity and cardiovascular depression was reserved by naloxone, a specific opioid receptor antagonist; suggesting that an endorphinergic mechanism is involved in the inhibitory effect. This is supported by the finding of a marked increase in opioid peptide content in human CSF after TENS for 30mins[14].

In a study done by F Jacobsson, et al found reduction in mean systolic blood pressure by 6.3 mm Hg (P<0.05) and the mean diastolic blood pressure decreased by 3.7 mm Hg (P>0.05) after 4 weeks of application of burst TENS TENS at 2 acupoints (Hegu LI 4, Quchi LI 11) on both forearms for 30 minutes twice daily during 4 weeks Thus they concluded that continuous TENS may have additional blood pressure lowering properties in hypertensive patients who do not respond properly to pharmacological treatment. The effect of TENS may also have a prolonged effect6.

John Zhang ,Derek Ngb, Amy Saub (2008) concluded that electrical stimulation of acupuncture points reduced systolic blood pressure but not the diastolic blood pressure in the current subject population with normal and elevated blood pressure Used the acupuncture points LI 4 and LI 11 for blood pressure for 30 minutes each session, twice a week for 5 weeks.

The stimulation of acupuncture points triggers the release of opioid chemicals in the brain that reduce excitatory responses in the cardiovascular system. This decreases the heart's activity and its need for oxygen, which in turn can lower blood pressure, and promotes healing for a number of cardiac ailments, such as myocardial ischemia (insufficient blood flow to the heart) and hypertension[15].

In this study the effects of Burst TENS on blood pressure by stimulating certain acupuncture points and meridians in hypertensive subjects was seen. Selected acu-points LI 4 and LI 11are based on the published study of Zhou et al for 2 reasons. First, these 2 points were important in the traditional Chinese medicine and were most commonly used for varying conditions including hypertension. Second, these 2 points were on the upper arm so it is very easy for researchers to access and apply treatments15 . This approach was supported by the study of Jacobsson et al using the same Hans unit treating 2 points on the forearm showed significant reduction in blood pressure[15].

TENS produced a reduction in BP which may be associated with vasodilatation.It is suggested that an opioid-serotonergic mechanism or VIP (vasoactive intestinal polypeptide) as possible neurotransmitters involved in TENS induced vasodilatation.

The effect of low frequency TENS on hemodynamic and metabolic changes in the heart was seen and stated that an increase in peripheral microcirculation results from sympatho inhibition after the application of low frequency TENS.

The reduction in blood pressure due to Burst TENS may be caused by the central inhibition of the sympathetic activity

In a study, done by Sanderson et al to assess the effect of TENS or a variety of standard tests of autonomic cardiovascular reflexes concluded that TENS appeared to have a mild inhibitory effect on reflexes which are mediated predominantly by the sympathetic nervous system[16].

Kaada etal investigated the effect of low freq TENS on hemodynamic and metabolic changes in the heart and stated that an increase in peripheral micro circular results from sympathoinhibition after the application of low frequency TENS[14].

Burst-mode stimulation was chosen in order to mimic the naturally occurring, burst-like pattern of action potentials in sympathetic nerves. The pattern of external stimulation more closely mimics physiologic sympathetic nerve activity than continuous mode stimulation does Vasodilatation would be more likely to occur with burst-mode than with constant-frequency TENS because arterial smooth muscle is more responsive to irregular, low-frequency bursts of stimulation. The muscle pump, accumulation of local metabolic vasodilator substances and flow induced vasodilatation produced by local release of reflexing factors derived from the endothelium are potential mechanisms for the vasodilation in response to the TENS[5].

Also Blood pressure response to exercise after Burst TENS application in the experimental group was significantly lower than in the control group thus it proves that Burst TENS application helps to reduce the exaggerated Blood pressure response to exercise . Thus Burst TENS can help to reduce the exaggerated blood pressure response to exercise and aid in prescription of safe exercise and prevent further cardiovascular injury.

Impaired exercise tolerance in hypertensive patients defined by functional exercise testing can be used to assess new drugs for hypertension treatment, adequacy of exercise blood pressure control, and the search for appropriate therapy for diastolic dysfunction in relation to

Burst TENS can be safely used adjunct to drug therapy to lower the abnormal exaggerated blood pressure response to exercise in hypertensive patients.

V. CONCLUSION

The results of this study shows that there was immediate statistical and clinically significant reduction in Blood pressure after the application of Burst TENS. Hence patients with exaggerated response of Blood Pressure with exercise can be benefitted with application of burst TENS.

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Figure 1. Placement of TENS Electrodes

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Table No. 1 Comparison of Blood pressure variables pre and post Burst and Sham TENS

Variables	Burst TENS				Sham TENS			
	Pre	Post	"t"	"p"	pre	Post	"t"	"p"
SBP	140.80±8.54	130.13±8.74	13.56	*0.000	141.67+9.09	141.27+9.60	1.795	0.083
DBP	92.13±4.20	83.47±4.17	12.87	*0.000	92.40+4.31	91.93+4.99	1.651	0.109
MAP	108.36±5.52	99.02±5.41	11.33	*0.000	108.8222+5.78	108.3778+6.38	1.000	0.326
PR	84.33±4.39	79.27±3.54	13.83	*0.000	84.33+4.39	84.27+4.47	1.720	0.096

SBP: Systolic Blood Presure; DBP: Diastolic Blood Pressure; MAP: Mean arterial Pressure PR: pulse Rate. * Significant

Table No.2: Comparison of mean change in blood pressure and heart rate variables from baseline after Burst and sham TENS

Parameters	Mean ± SD		't' value	'p' value	Result
	Burst TENS	Sham TENS			
SBP	10.67±4.31	0.40 ±1.22	12.55	p<0.05	Significant
DBP	8.67±3.68	0.47±1.54	11.39	p<0.05	Significant
MAP	9.37±3.69	0.43±1.35	12.62	p<0.05	Significant
PR	5.07 ±2.44	0.07±0.36	11.18	p<0.05	Significant

Table No.3: Mean difference of Pre-Post change in Variables of 6 MWT with burst and Sham TENS .

Variables	Pre Burst	Post Burst	't' value	'p' value	Pre Sham	Post sham	't' value	'p' value
SBP	35.67±3.48	23.67±5.99	11.47	P<0.05	35.33±4.080	35.67±4.205	-1.720	P>0.05

DBP	9.47±2.51	1.27±3.08	10.19	P<0.05	9.60±2.127	10.07±3.129	-1.651	p>0.05
MAP	18.33±2.10	8.77±3.03	13.58	P<0.05	18.20±2.203	18.60±2.699	-1.934	p>0.05
PR	36.63±6.18	21.30±8.78	11.20	P<0.05	36.20±4.909	36.00±4..00	0.291	p>0.05