Study of 24 Hours/2 day Monitoring of Blood Pressure in Subjects with Traumatic Paraplegia

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ABSTRACT

Cardiovascular dysfunction and cognitive decline are more common in traumatic spinal cord injury (SCI). Most people with a cervical or upper-thoracic SCI usually experience conditions called orthostatic hypotension and autonomic dysreflexia, which are described by the serious changes in systemic blood pressure. To evaluate baseline heart rate (HR), baseline blood pressure (BP) and ABPM monitoring in traumatic paraplegia patients. In this study, total 36 diagnosed of paraplegia patients was based on Asia Impairment Scale (AIS), paralysed by RTA, or fall from height within 7 days of injury were included in this study. The blood pressure was monitoring for 24 hour/2 day and repeated after 12th day of first monitoring. Ambulatory blood pressure was monitored by ABPM machine at HALF hourly from 6 am – 10 pm and one hourly from 10 pm – 6 am. All the continuous variables were compared by t- test. The night dipping (Systole) and morning surge (Systole) were significantly lower at 12th days as compared to within 7 Days ($p=0.002$). Whereas the diurnal Index (Diastole) and diurnal Index (MAP) were comparable in between within 7 days and 12th days. The mean SBP max and SBP min were significantly lower at 12th day as compared to within 7 days. Whereas DBP max and min were comparable in between within 7 days and at 12th days. The changes in min., max and mean double product (All, active periods, and passive periods) were also not found to be statistically significant in between within 7 days and at 12th day. The traumatic paraplegic patients have altered diurnal index, morning surge, night dipping and systolic blood pressure on APBM monitoring.

Keywords: Paraplegic, Heart rate, Blood pressure, Trauma, Spinal cord injury.

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I. INTRODUCTION

The traumatic spinal cord injury can cause sensory, motor just as autonomic weakness prompts cardiovascular system dysfunction as a result of the disturbance in the autonomic nervous pathways, leading to complications such as orthostatic hypotension (OH) and autonomic dysreflexia (AD) [1]-[3]. The cardiovascular disease (CVD) has become a significant wellspring of morbidity and mortality in spinal cord injury individuals [4], [5]. Within the sight of relentless hypotension and orthostatic hypotension show as surprising changes in blood pressure and heartbeat rate, can cause a scope of signs that may provoke limitations in activities the of day by day living or serious clinical and neurological results [6]. The level of injury may increase the risk of CVD such as the impairment in autonomic regulation of cardiovascular that

causes instability in blood pressure (BP) [7], [8]. Furthermore, to these variations in blood pressure and heart rate, the deficiency of thoughtful information is additionally connected with diminished diurnal variety in BP relying upon the level and seriousness of injury [1], [9].

Worldwide, the of spinal card injury (SCI) range from 40 to 80 cases/million yearly [10]-[12]. The SCI included the functional disability, loss of autonomy, mortality, morbidity, and great lifetime costs, including the criticalness of limiting the course of damage to the microenvironment around the injury [13].

The ambulatory blood pressure monitoring (ABPM) is a valuable tool monitor circadian BP profiles, which have been demonstrated to be of acceptable prognostic incentive for cardiovascular bleakness and mortality in physically fit [14].

The central nervous system (CNS) is a crucial part of the body which contains brain and spinal cord. The spinal cord is a thick long structure made up of nervous tissue which extends caudally and is protected by the surrounding (CSF) cerebral spinal fluid and bony vertebra column which prevents the fragile nerve tissue [15], [16]. The nerves connecting the spinal cord to the body are called the Peripheral Nervous System. Any trauma of spinal cord can affect conduction of both sensory and motor signals across the site(s) of lesion(s), as well as the autonomic nervous system. By doing systematic examination the dermatomes and myotomes, we can determine the cord segments affected by the SCI [5]. In this study we aim to evaluate the increasing risk of developing cardiovascular morbidity and mortality in traumatic paraplegia patients.

II. MATERIAL AND METHODS

This cross-sectional study was carried out in spinal injury unit of Orthopaedic department, King Georges Medical University; Lucknow after getting approval from Ethical committee of King Georges Medical University, Lucknow (Ref. code – 96th ECM II B – Thesis/P28). Total 36 patients paralysed by RTA or fall from height within 7 days of injury were included in this study. Patients with > 70 yrs, unconscious, any spinal tumor and other known endocrinal and cardiovascular disease non traumatic paraplegia and other known neurological deficit were excluded from the study. Informed written consent was obtained from each patient on the prescribed consent form.

Diagnosis of paraplegia patients was based on Asia Impairment Scale (AIS); Motor function grading and sensory grading [17], [18]. The cases were diagnosed on the basis of presenting symptoms of the patient (Table I).

Differentiation between complete and incomplete paraplegia was done by clinical sensory and motor examination. The patient usually suffers from loss of sensation, loss of mobility and variability in blood pressure. Other common symptoms are respiratory insufficiency, inhibition of bladder and bowel movement, urinary retention, and abdominal pain.

A comprehensive history was carefully obtained with special reference to their past medical history, personnel history. Also, history of dietary, smoking, alcohol and any kind of substance abuse were recorded. A quick general physical examination including blood pressure, pallor, icterus, lymphadenopathy, bed sore was performed. To rule out any systemic illness, a quick systemic examination of respiratory, abdominal, cardiovascular, system was also carried out. Detailed Neurological examination was performed which includes sensory examination and motor examination and this examination was repeated again before discharge of patient.

The recruited subject within 7 days of their paraplegia was subjected to blood pressure monitoring for 24 hour/2day while they are admitted in the traumatic paraplegia wards in Orthopaedics department. The blood pressure monitoring was repeated after 12th day of first monitoring. Both set of data was subjected to COSINOR analysis software and they were compared to find out statistical significance. Ambulatory blood pressure was monitored by ABPM machine at HALF hourly from 6 am – 10 pm and ONE hourly from 10pm - 6am.

A. Statistical Analysis

The sample size was calculated on the basis of SD's of SBP in Tetraplegics and paraplegics with 90 per cent of power and 95% confidence level. [20] The data is expressed as mean, standard deviation (SD) and percentage as appropriate. All the continuous variables in two groups were compared by t- test. The p-value <0.05 was considered as significant. The statistical analysis was done using SPSS 23.0 version (Chicago, Inc., USA) windows software.

III. RESULTS

The mean±SD age (years) of the patients were 33.79±11.05, gender. Among all the subjects, males were in majority with 27 (79.41%) proportion and rest 7 (20.59%) were females. Most of the subjects were laborers (47.1%) while among women majority were housewives (14.7%). Students were 14.7%. Fall from height was the major mode of injury which was observed in 44.1% cases. RTA was the second most common mode of injury which was observed in 20.6% cases. Other mode of injuries was fall from tree (17.6%), fall of heavy object (8.8%), fall from stairs (5.9%) and fall from bike (2.9%). The AIS grades A, B, C and E were found in proportion 70.6%, 20.6%, 5.9% and 2.9% respectively in the study. The involuntary BBI was found in 88.2% cases while voluntary BBI was found in 11.8% cases. The most frequently neurological injury was L1 which was observed in 15 (44.1%) cases separately and combined with T12 in one case. Other frequent injuries were T10 (14.7%), T12 (11.8%+2.9% with L1), T11 (8.8%) etc. Among the total 34 injuries, 22 (64.7%) were of the complete nature while 12 (35.3%) were of the incomplete nature (Table II).

Changes in Diurnal Index (Diastole), Diurnal Index (MAP), night dipping (Systole) and Morning Surge (Systole) from within 7 days to at 12th day. The mean value of Diurnal Index (Diastole) within 7 days was 3.76±3.64 which was changed to the mean 2.35±5.22 at 12th day. The mean value of Diurnal Index (MAP) within 7 days was 3.26±2.96 which was changed to the mean 2.26±4.19 at 12th day. The mean value of night dipping (Systole) within 7 days was which was changed to the mean at 12th day. The mean value of Morning Surge (Systole) within 7 days was 5.24±6.32 which was changed to the mean 0.56±5.05 at 12th day. Moreover, the night dipping (Systole) and morning surge (Systole) were significantly lower at 12th Day as compared to within 7 days (p=0.002). Whereas the diurnal Index (Diastole) and diurnal Index (MAP) were comparable in between within 7 days and 12th days (Table III).

Comparison DBP (Max), DBP (min.), SBP (Max) and SBP (Min) in between within 7 days and at 12th day. The mean value of DBP (Max) within 7 days was 77.38±9.12 mmHg which was changed to the mean 77.15±9.92 mmHg at 12th day. The mean value of SBP (Max) within 7 days was 124.74±14.78 mmHg which was changed to the mean 118.59±14.44 mmHg at 12th day. The mean value of DBP (Min) within 7 days was 62.38±9.44 mmHg which was changed to the mean 61.44±9.17 mmHg at 12th day. The mean value of SBP (Min) within 7 days was 105.26±13.43 mmHg which was changed to the mean 100.06±9.89 mmHg at 12th day. The mean SBP max and SBP min were significantly lower at 12th day as compared to within 7 days. Whereas DBP

max and min were comparable in between within 7 days and at 12th day (Table IV).

Changes in min., max., and mean Double Product (All, active periods, and Passive Periods). The mean value of Double Product (All) Min within 7 days was 7231.76±1595.19 which was changed to the mean 7473.00±1452.44 at 12th day. The mean value of Double Product (All) Max within 7 days was 13104.85±3046.42 which was changed to the mean 13224.53±3100.06 at 12th day. The mean value of Double Product (All) Mean within 7 days was 9761.65±9831.82 which was changed to the mean 9831.82±1693.83 at 12th day. The changes in min., max and mean double product (all) were not found to be statistically significant in between within 7 days and at 12th day (Table V).

The mean value of Double Product (Active Periods) Min within 7 days was 7683.06±1767.16 which was changed to the mean 7726.47±1399.70 at 12th day. The mean value of Double Product (Active Periods) Max within 7 days was 13066.24±3007.52 which was changed to the mean 13210.29±3109.18 at 12th day. The mean value of Double Product (Active Periods) Mean within 7 days was 10023.79±2206.40 which was changed to the mean 10037.79±1665.92 at 12th day. The changes in min., max and mean double product (Active Periods) were not found to be statistically significant in between within 7 days and at 12th day.

The mean value of Double Product (Passive Periods) Max within 7 days was 11065.65±2940.82 which was changed to the mean 10925.68±2357.67 at 12th day. The mean value of Double Product (Passive Periods) Min within 7 days was 7846.82±2302.57 which was changed to the mean 7768.47±1697.59 at 12th day. The mean value of Double Product (Passive Periods) Mean within 7 days was 9243.91±2576.73 which was changed to the mean 9162.03±1820.72 at 12th day. The changes in min., max and mean double product (Passive Periods) were also not found to be statistically significant in between within 7 days and at 12th day.

TABLE I: MUSCLE FUNCTION GRADING, SENSORY GRADING AND ASIA IMPAIRMENT SCALE (AIS) FOR PARAPLEGIA [17], [18]

Muscle Function Grading	
0	Total paralysis
1	Palpable visible contraction
2	Active movement, full ROM against with gravity eliminated
3	Active movement, full ROM against gravity
4	Active movements, full ROM against gravity and moderate resistance in a muscle specific position
5	Active movement, full ROM against gravity and full resistance in a functional muscle position expected from an otherwise unimpaired person.
Sensory Grading	
0	Absent
1	Altered, either decrease /impaired sensation or hypersensitivity
2	Normal
Asia Impairment Scale (AIS) for paraplegia	
A	Complete→ No sensory or motor function is preserved in the sacral segment s4-s5
B	Sensory incomplete→Sensory but not motor function is preserved below the neurological level preserved
C	Motor incomplete→Motor function is preserved a the most caudal sacral segment for voluntary anal contraction
D	Motor incomplete
E	Normal

TABLE II: BASELINE CHARACTERISTICS OF PATIENTS

	mean±SD
Age	33.79±11.05
Gender	n (%)
Male	27 (79.4%)
Female	7 (20.6%)
Occupation	
Student	5 (14.7%)
Skilled Laborer	4 (11.8%)
Unskilled Laborer	16 (47.1%)
Farmer	4 (11.8%)
Housewife	5 (14.7%)
Mode of Injury	
Fall from bike	1 (2.9%)
Fall from height	15 (44.1%)
Fall from stairs	2 (5.9%)
Fall from tree	6 (17.6%)
Fall of heavy object	7 (20.6%)
RTA	3 (8.8%)
Type of Injury	
Complete	22 (64.7%)
Incomplete	12 (35.3%)
AIS Grade	
A	24 (70.6%)
B	7 (20.6%)
C	2 (5.9%)
E	1 (2.9%)
BBI	
Involuntary	30 (88.2%)
Voluntary	4 (11.8%)
Neurological	
L1	15 (44.1%)
L2	1 (2.9%)
L3	1 (2.9%)
T10	5 (14.7%)
T11	3 (8.8%)
T12	4 (11.8%)
T12, L1	1 (2.9%)
T4	1 (2.9%)
T8	2 (5.9%)
T9	1 (2.9%)

TABLE III: THE CHANGES IN DIURNAL INDEX (DIASTOLE), DIURNAL INDEX (MAP), NIGHT DIPPING (SYSTOLE) AND MORNING SURGE (SYSTOLE) FROM WITHIN 7 DAYS TO AT 12TH DAY

	n	Within 7 Days		n	At 12 Days		p-Value
		Mean	±SD		Mean	±SD	
Diurnal Index (Diastole)	34	3.76	3.64	34	2.35	5.22	0.153
Diurnal Index (MAP)	34	3.26	2.96	34	2.26	4.19	0.205
Night dipping (Systole)	31	3.38	2.82	23	1.44	3.70	0.009*
Morning Surge (Systole)	30	5.24	6.32	20	0.56	5.05	0.002*

*=Significant (p<0.05).

TABLE IV: COMPARISON DBP (MAX), DBP (MIN.), SBP (MAX) AND SBP (MIN) IN BETWEEN WITHIN 7 DAYS AND AT 12TH DAY

	Within 7 Days		At 12 th Day		p-Value
	Mean	±SD	Mean	±SD	
DBP (Max)	77.38	9.12	77.15	9.92	0.881
SBP (Max)	124.74	14.78	118.59	14.44	0.003*
DBP (Min)	62.38	9.44	61.44	9.17	0.633
SBP (Min)	105.26	13.43	100.06	9.89	0.033*

*=Significant (p<0.05).

TABLE V: CHANGES IN MIN., MAX., AND MEAN DOUBLE PRODUCT (ALL, ACTIVE PERIODS, AND PASSIVE PERIODS)

	Within 7 Days		At 12 th Day		p-Value
	Mean	±SD	Mean	±SD	
Double Product (all) Min	7231.76	1595.19	7473.00	1452.44	0.385
Double Product (all) Max	13104.85	3046.42	13224.53	3100.06	0.857
Double Product (all) mean	9761.65	2290.68	9831.82	1693.83	0.855
Double Product (Active Periods) Min	7683.06	1767.16	7726.47	1399.70	0.883
Double Product (Active Periods) Max	13066.24	3007.52	13210.29	3109.18	0.826
Double Product (Active Periods) mean	10023.79	2206.40	10037.79	1665.92	0.969
Double Product (Passive Periods) Min	7846.82	2302.57	7768.47	1697.59	0.832
Double Product (Passive Periods) Max	11065.65	2940.82	10925.68	2357.67	0.800
Double Product (Passive Periods) mean	9243.91	2576.73	9162.03	1820.72	0.852

IV. DISCUSSION

Over the past decade, numbers of spinal cord injury patient are increasing at a very high rate and also, the cardiovascular morbidity and mortality among them. Both of them possess a great clinical and economic burden over the society. Previous studies have illustrated that cardiovascular changes in spinal cord injury increases the risk of cardiovascular morbidity and mortality [14]. Possible cause for this may be the Autonomic Dysreflexia, spinal shock, increase in shear stress of blood vessels and cessation of normal daily blood pressure fluctuations which are seen in healthy individuals [14], [19]. Also, these patients live unhealthy lifestyle which includes smoking, physical inactivity, and an unhealthy diet. Long term ambulatory loss in these patients leads to numerous cardiovascular risks like Coronary Artery Disease (CAD), hypertension, cardiovascular disease, valvular disease, and dysarrhythmias [20]. SCI decreases autonomic neural control over cardiovascular function with the most severe effects on BP control when the injury occurs above the 6th thoracic segment [21]. The change in blood pressure rhythm in tetraplegic subjects, show a loss of nocturnal dip [22]. The level of lesion plays a major role in the preservation of circadian rhythm. The SCI subjects with either low thoracic or high thoracic lesion show a preserved nocturnal dip, compared with cervical SCI lesion [22]. Studies conducted in past few years have proven that Ambulatory blood pressure monitoring technique helps in recording multiple blood pressure readings over 24 hour period, whether the patient is awake or asleep. Thus, proving itself as a valuable instrument for knowing Cardiovascular risk in patients with Spinal Cord Injury [23].

In the present study, it was seen that maximum number of cases falls in the age group of 21-30 years. The findings coincide with previous data available to us which shows that majority of cases of SCI are between the age group of 16-30 years [24]. The probable cause for such finding may be that this age group comprise of most active individuals. These

people spend much of their time travelling on roads and are thus, prone to accidents. Also, this age group comprises laborers working at construction sites that are prone to fall and get spinal cord injury.

In our study, it was observed that majority of cases were males as compared to females. Similarly, previous study shows that the males are more prone than females to develop traumatic paraplegia at any age group [25]. The probable reason for this increased male to female ratio might be that majority of women are dealing with household work only and males are more active in outside work.

In the present study, distribution of patients according to their occupation depicted that most of the cases were Labourers and mode of injury was fall from height. The data available from previous studies was not in agreement with our observations which showed that automobile crashes are the major cause of SCI [26]. The reason might be that as the present study was conducted in government set up and majority of the patients i.e., laborers coming to the hospital belongs to lower socioeconomic status.

In the present study, maximum number of cases lies in AIS– A than AIS– B grading of traumatic paraplegia patients. Various previous studies demonstrated that the majority of traumatic paraplegia patients fall under A grade of AIS scoring [14], [27].

In the present study, distribution of subjects according to Bladder and Bowel involvement shows that majority of cases have involuntary control. Similar findings were observed in previous studies which demonstrated that bladder becomes atonic, and conscious awareness of bladder filling is lost [28]. This occurs due to interruption of the neural conduction below the level of pons and thus abolish micturition reflex, which causes retention of urine in spinal cord injury patients.

In the present study, the majority of cases have L1 level and T12 was second most common neurological involvement. A study demonstrated that the most common level of the spinal cord injury is cervical spine [29], [30]. The probable cause for this may be due to the maximum impact of injury on L1 because it is present at end of kyphosis and beginning of lordosis of spine.

In our study, the frequencies abnormal diurnal index was significantly increased with time pass. This change in circadian BP may be due to the sympathetic nervous system. During sleep, the sympathetic nervous system remains quiescent whereas, in the early morning, BP rises sharply due to activation of same [14]. Other possible cause which might not be that significant is, during the sleep BP cuff inflate and deflate which causes disturbance in sleep of the patient and further reduces the BP fluctuations due to awakening [31]. Also, in patients of SCI physical activity is lost due to paralysis of lower limbs which further leads to loss of normal circadian fluctuations in BP [32], [33]. Previous study shows that circadian BP changes are also contributed by mental and physical activities of the individual [34]. Another study also found that in patients with thoracic spinal cord injury, Diurnal variation of blood pressure is lost. The above findings matched with our result [35]. The loss of diurnal variation of blood pressure leads to hemodynamic changes resulting in cardiovascular diseases like hypertension, stroke, orthostatic hypotension, valvular disease etc. Thus, resulting in increased risk of cardiovascular morbidity and mortality in SCI patients.

In the present study, we found significant positive correlation of SBP in diurnal Index between within 7th day and 12th day of ABPM monitoring. No significant correlation was seen in DBP and mean arterial pressure in diurnal index between within 7th day and 12th day of ABPM monitoring. In best of my knowledge, I was unable to find any relevant data about SBP, DBP and MAP in Diurnal Index separately in patients with SCI.

It is the differences of mean blood pressure (%) between awake and sleep period. In normal healthy individuals a rise in BP is seen upon awakening in the morning during ambulatory BP monitoring. The underlying mechanisms for this surge in BP in the morning are change in posture, activation of sympathetic nervous system, renin-aldosterone system activation, and cortisol system activation [36]. In the present study we found that within 7th day of ABPM monitoring 4 patients shown absence of morning surge while 30 were having normal morning surge. On 12th day of ABPM monitoring, number of patients showing absence of morning surge increased to 13. A significant positive correlation of morning surge was seen between within 7th day and 12th day of ABPM monitoring. The possible cause for this might be the loss of supraspinal and autonomic nervous system control over the cardiovascular system.

In our study we found significant positive correlation of systolic blood pressure within 7th day and 12th day of ABPM monitoring. According to pathophysiology of SCI, immediately after the spinal cord injury blood pressure rises then as few days passes by, systolic blood pressure keeps on falling due to failure of compensatory mechanism responsible for vasoconstriction. The compensatory mechanism includes changes in sympathetic activity within large vascular beds, like skeletal muscle and splanchnic circulation and decreased venous return resulting in decreased cardiac output following low systolic blood pressure. This reduced systolic blood pressure improves within days to weeks due to activation of compensatory mechanisms like spinal sympathetic reflexes, skeletal muscular tone, and rennin-angiotensin-aldosterone system and increased the blood pressure after few days of injury [36]. The probable cause for this change in blood pressure might be spinal shock which leads to loss of supraspinal modulation, altered spinal neurotransmitters balance, sympathetic system failure and parasympathetic system dominance [36]. The systolic blood pressure levels remain normal with circadian rhythm in patients with paraplegia which does match with our findings [37].

In this study we did not found any significant correlation of diastolic blood pressure within 7th day and 12th day of ABPM monitoring in patients of paraplegia. Nitsche et, al conducted a study and found that systolic blood pressure levels remain normal with circadian rhythm in patients with paraplegia which matches with our findings [37]

In this study the normal dipping pattern was found 31 (91.18%) patients at 7th day and 23 (67.65%) at 12th day of ABPM monitoring. The possible cause for this nocturnal dipping in blood pressure might be the inhibition of Sympathetic Nervous System from supraspinal centers in brain. As we know that paraplegia patients are unable to do any daily physical activity due to paralysis of lower limbs, thus sympatho-excitatory drive is absent in these patients resulting in reduced day time blood pressure. This results in

loss of nocturnal dip. Previously a study found that in patients with thoracic spinal cord injury, night dipping in blood pressure is lost. The above findings matched with our result [35]. Previous study showed that paraplegia patients have preserved nocturnal dip while tetraplegia patients have loss of nocturnal dip in ABPM which is not in agreement with our findings [14].

V. CONCLUSION

In the present study we can conclude that traumatic paraplegic patients have altered diurnal index, morning surge, night dipping and systolic blood pressure on APBM monitoring. Looking at the current scenario of increasing risk of developing cardiovascular morbidity and mortality in traumatic paraplegia patients, it is of great importance to identify a simple, cost effective, non-invasive and reliable marker with proper understanding of their relationship with disease for screening purpose.

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