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Effect of Arm Spasticity Grade on Blood Pressure Measurement

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Original Article

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Objective: The arm spasticity in patients with stroke has been proved to affect blood pressure measurement. However, earlier studies showed inconsistent results of how the spasticity affected the measurement of blood pressure. In some cases, measurement of blood pressure in patients' involved arm is necessary, so the purpose of this study was to investigate the effect of spasticity grade on blood pressure measurement in patients with stroke.

Methods: We recruited 50 patients with hemiplegia or hemiparesis after stroke. The grade of arm spasticity was assessed using the modified Ashworth scale (MAS), while the bilateral brachial artery pressure was measured using an electronic sphygmomanometer. Differences in blood pressure between normal and involved arm were compared using student's *t*-test. We used ANOVA to analyze group differences in blood pressure changes at different grades of spasticity, and performed Spearman rank correlation to evaluate the correlation between different spasticity levels and differences in mean blood pressure.

Results: Inter-arm blood pressure showed no significant difference when the grade of arm spasticity was low (MAS=0, 1, 1+), but blood pressure on the involved side was higher than normal side when the spasticity grade was high (MAS≥2). Differences in spasticity grade were positively correlated with inter-arm differences in blood pressure (Spearman rank correlation coefficient=0.43; $p<0.05$).

Conclusions: Grade of arm spasticity may affect blood pressure measurement. Higher blood pressure on the spastic arm may be measured in patients with severe spasticity (MAS≥2). (Tw J Phys Med Rehabil 2013; 41(3): 173 - 180)

Key Words: blood pressure, spasticity, modified Ashworth scale

INTRODUCTION

High blood pressure is closely related to cerebrovascular and cardiovascular diseases, for example, hypertension is an important risk factor for stroke, coronary artery disease, and heart failure.[1-3] These diseases are the leading causes of death in Taiwan and the United States;[1] therefore, it is important to monitor and control blood pressure in these patients. Studies have shown that hypertension detection and management can reduce the incidence and recurrence rate of stroke and other dis-

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eases.[4,5] The most common method to monitor blood pressure is through the use of a sphygmomanometer. However, measurement of blood pressure may be influenced by many factors, including patient posture and arm position,[6-8] cuff size,[9] cuff position, and sphygmomanometer types(oscillometric and auscultatory type).[10-12] In addition, the blood pressures of left and right arm are usually different.[13]

According to the recommendations of the American Heart Association (AHA), accurate measurement of blood pressure is achieved when the blood pressure is measured in both arms first and then in the arm with the higher pressure.[14] However, patients with stroke often have some spasticity in the involved arms, which has been proved to affect blood pressure measurement, causing differences in blood pressure between the involved and normal arms. Also, there is still no consensus on whether the blood pressure in the involved arm is higher or lower than that in the normal arm.[15-18]

Dewar et al studied 103 patients with hemiplegic arms after stroke and found that 56 patients with flaccid arms had lower blood pressure in the involved arm than in the normal arm, while other 41 patients with spastic arms had higher blood pressure in the involved arm than in the normal arm.[15] Panayiotou et al studied 15 patients with flaccid hemiparesis after stroke and the results showed that 7 had lower blood pressure on the involved side; whereas 8 had higher blood pressure on the involved side.[16] Moorthy et al studied 9 patients with spasticity after stroke and found that 5 had higher blood pressure on the involved side; whereas 4 had lower blood pressure on the involved side.[17] Yagi et al studied 47 patients with hemiparetic arms after stroke and found that regardless of tension, average systolic pressure and diastolic pressure was 2 mmHg and 5 mm Hg higher in the involved arm than in the normal arm, respectively.[18]

To date, no studies have investigated on whether the conflicting results of these earlier studies are due to the different grades of spasticity in the subjects' arms. In addition, it is necessary to measure blood pressure on the involved arms in some clinical cases. For example, when the normal arm is prohibited from receiving therapy, such as hemodialysis fistula on the arm and after axillary lymph nodes dissection, or when patients have bilateral spasticity, due to bilateral stroke and cervical spinal cord injury. Therefore, it is necessary to investigate the effect of the grade of spasticity on blood pressure measurement. In this study, we measured blood pressure in patients with stroke and compared the value between their involved and normal arms to evaluate the effect of the grade of arm spasticity on the measurement of blood pressure. We hope that this study can be a reference for the future measurement of blood pressure in patients with stroke.

MATERIALS AND METHODS

Patients

This study was conducted at the Tao Yuan General Hospital, Taiwan. The eligible participants were consecutively admitted inpatients with stroke in the rehabilitation clinic, and they (1) had to be over 20 years of age and (2) should be diagnosed unilateral hemiplegia or hemiparesis. Exclusion criteria were as follows: (1) contraindicated to measure blood pressure in one or both arms because of conditions such as hemodialysis fistula on the arm, or post axillary lymph node dissection, (2) bilateral arm spasticity such as that found in bilateral stroke, and (3) history of subclavian artery stenosis or coarctation of the aorta.

Evaluation method

Differences of blood pressure in both arms were obtained by subtracting mean blood pressure (MBP) in the normal arm from MBP in the involved arm. MBP was calculated using the formula: MBP (mmHg)=1/3SBP (systolic blood pressure)+2/3DBP(diastolic blood pressure). The modified Ashworth scale (MAS) was used to evaluate the arm spasticity in patients by the method of "manually moving a limb through the range of motion to passively stretch specific muscle groups".[19] Based on the resistance encountered during the passive stretch, the grade of spasticity was classified into five levels.[19] We tested the spasticity of elbow flexor muscle group by extending the patient's elbow from a position of maximal possible flexion to maximal possible extension for approximately one second.[19] The motor recovery of patients was evaluated based on Brunnstrom stage of motor recovery approach.[20]

Study procedure

At the beginning of the study, all patients were asked to rest for 5 minutes. A physiatrist then measured the arm spasticity of participants based on MAS and assessed their movement recovery based on Brunnstrom stage. The brachial artery pressure of participants was measured in both left and right arms by an electronic sphygmomanometer (Criticare Systems Inc. 506DXN). During the measurements, the subjects were asked to maintain arms and hearts at the same height. The appropriate cuff size was placed 2–3 cm above the antecubital fossa of subjects. In each subject, the sequence of blood pressure measurement in involved and normal arm was randomly chosen and performed at a 2-minute interval. Three measurements were carried out in each side. This study was approved by the medical ethics committee of the Taoyuan General Hospital. Consent forms were completed by each subject or their legal representative.

Statistical analysis

SAS (SAS Institute Inc, Cary, NC, USA) statistical software was used to analyze the results of arm spasticity and MBP. Because blood pressure values were normally distributed, 2-tailed paired t test was used to determine whether there were significant differences between the MBP of the involved and normal arms. We also compared the inter-group difference between different genders, stroke subtypes, and stroke sides by using 2-tailed unpaired t test. Analysis of variance (ANOVA) was used to evaluate whether there were significant differences between the inter-arm differences in MBP of groups with varying grades of spasticity, Brunnstrom stage, and age. Post-hoc analysis was performed using Fisher's protected least significant difference test (LSD test) to determine the correlation between inter-arm differences in MBP and the grade of spasticity. Finally, because MAS score was an ordinal variable, Spearman rank correlation was used to evaluate the correlation between the grade of spasticity and MBP. MAS 1 and 1+ were combined in the calculation during Spearman rank correlation. p-value < 0.05 was considered statistically significant.

RESULTS

Fifty subjects with age ranging from 32 to 88 years old (mean=58.2 years, S.D.=12.4 years) were recruited in this study. All patients suffered from stroke within one year. Fourteen (28%) patients were female, twenty-four (48%) patients had right hemiparesis or hemiplegia, one patient (2%) was left-handed, and twenty-two (44%) patients had ischemic stroke. The number of subjects with MAS score of 0, 1, 1+, 2, 3, and 4 was 9, 16, 11, 8, 6, and 0, respectively.

We investigated the effect of gender, age, stroke side, Brunnstrom stage, stroke subtype, and grade of spasticity on the inter-arm differences in blood pressure. Results showed that the MBP were statistically different between normal and involved arms in all patients ($p<0.01$) (Table 1). For different age, Brunnstrom stage, and grade of spasticity, the inter-group differences were significant ($p<0.05$); in contrast, for different gender, stroke side, and stroke subtype, there was no significant differences among groups($p>0.05$)(Table 1). In addition, the effect of arm spasticity on the MBP differences between normal and involved arms depended on the grade of spasticity. For patients classified in MAS 2 and 3, the MBP between two arms were significantly different; whereas patients classified in MAS 0, 1, and 1+, the MBP were similar between two arms. Post hoc analysis revealed a similar trend that inter-arm MBP difference of patients classified in MAS 0 and MAS 2 group, MAS 0 and MAS 3 group, and MAS 1 and MAS 3 group showed statistic differences. This obviously indicated that high grade of spasticity (MAS≥2) caused inconsistent measurement of blood pressure in normal and involved arms. Further, the level of motor recovery of patients also affected the MBP differences between normal and involved arms. For patients classified in Brunnstrom stage III, the MBP between two arms were significantly different; whereas for patients classified in Brunnstrom stages II, IV, and V, the MBP were not significantly different between two arms (Table 1). We further investigated the correlation between MBP and the grade of arm spasticity. Results showed that MBP were significantly positively correlated ($p<0.05$) with MAS score (Spearman rank correlation coefficient=0.43), indicating that patients after stroke with higher MAS score had larger differences in blood pressure. This indicated that in the evaluation of patients' spasticity in clinic, patients with higher MAS score showed higher differences in blood pressure between their involved and normal arms.

Table 1. Average of mean blood pressure (mmHg) of all patients and subgroups

			Normal arm		Involved arm		Statistical analysis	
Category	Variable	n	Mean	S.D.	Mean	S.D.	Inter-arm	Inter-group
All		50	100.41	12.88	102.68	11.75	*	
Sex	Female	14	99.9	11.61	104.3	12.04	*	-
	Male	36	100.6	13.50	102.0	11.75	-	
Age	≤ 45	8	107.9	14.99	109.2	10.82	-	*
	45<AGE<65	28	99.6	12.76	100.7	12.57	-	
	≥ 65	14	97.7	11.06	103.0	9.74	*	
Weak-side	Left	26	99.3	14.12	101.7	13.18	*	-
	Right	24	101.6	11.58	103.8	10.16	-	
Brunnstrom stage	II	16	102.4	10.17	104.0	9.58	-	*
	III	12	96.6	12.97	102.8	12.38	*	
	IV	10	91.6	11.69	93.4	10.91	-	
	V	12	108.9	12.14	108.5	11.08	-	
Type	Hemorrhagic	28	103.8	14.01	105.1	12.66	-	-
	Ischemic	22	96.2	10.06	99.7	9.96	*	
MAS	0	9	107.5	14.22	106.1	14.80	-	*
	1	16	102.5	12.72	104.0	10.15	-	
	1+	11	93.9	11.37	96.8	12.82	-	
	2	8	96.0	9.27	100.0	6.17	*	
	3	6	102.0	14.34	108.3	12.65	*	

S.D.: standard deviation; Inter-arm: Statistical difference between the MBP of normal and involved arms; Inter-group: Statistical difference of groups with varying gender, age, weak side, Brunnstrom stage, stroke types, and grades of spasticity; * denotes $p<0.05$.

DISCUSSION

For patients with stroke, there are no instructions indicating whether the arm with the higher pressure or the normal arm should be measured. In clinic, the normal arm of patients after stroke, instead of the arm with higher blood pressure, is usually chosen for blood pressure measurements. Fonseca-Reyes measured blood pressure in 111 hypertensive and 80 normotensive patients in both arms, and observed no significant differences in the blood pressures of both arms.[21] However, some studies have found that the blood pressure in the involved arm was different from that in the normal arm.[15-17] In our study, the results showed that the blood pressure measured on the involved and normal sides were different only in stroke patients with severe spasticity.

Only a few studies have been conducted to identify the reasons for the differences in blood pressure of the involved and normal arms after stroke. Some studies indicate that these differences may be associated with spasticity.[15] With the emergence of spasticity, muscle tone increases may result in contractures.[22]

Earlier studies on the effect of spasticity on blood pressure did not show consistent results indicating an increase or decrease in blood pressure.[15-17] Our results indicated that the inconsistencies in the earlier studies were probably due to differences in the grade of spasticity in patients. If the grade of spasticity was low (MAS=0, 1, and 1+), the blood pressure measured on the involved or normal arm showed no statistically significant differences. However, if the grade of spasticity was high (MAS=2 and 3), the blood pressure measured on the involved arm was significantly higher than that the normal arm, a finding that was consistent with the results of Dewar et al.[15]

Our results also showed age differences affected the measurement of blood pressure. For patients aged > 65, blood pressure on the involved arm was higher than that on the normal arm, while no differences were observed in the groups of age < 65. The blood pressure on the involved arm was higher than the normal arm in patients with ischemic stroke too, and no differences were observed in patients with hemorrhagic stroke. These may be related to atherosclerosis process,[23] which was associated with inter-arm blood pressure difference.[24] Aging can induce vascular oxidative stress, progenitor cell deficits and then lead to atherosclerosis process.[25] Ischemic stroke is also strongly associated with atherosclerotic cerebrovascular disease.[26] For patients in Brunnstrom stage III, blood pressure in the involved arm was higher than normal arm, but no differences were observed in patients in the other stages. In stage III, patients develop voluntary movement with synergy pattern and maximal spasticity.[27] Therefore, patients in Brunnstrom stage III showed significant blood pressure differences between arms, which may be related to the degree of spasticity. For patients in Bruunstrom stage II and IV, blood pressure in the involved arm was also higher than the normal arm but not statistically significant. Future study to include more patients is necessary to prove our observation.

Previous studies suggested that blood pressure between left or right arms in normal subjects was not significantly different, and that the difference in inter-arm blood pressure was not correlated with gender.[28,29] Our results were consistent with previous studies that there were also no inter-group differences in different genders and weak-side groups. Our studies, however, showed that blood pressure between right and left arms were different only in female subjects but not in male subjects, and in left hemiplegic patients but not in right hemiplegic patients. This may be due to the limited number of participants included in our study.

Our study showed that no significant differences in blood pressure of normal and involved arm when spasticity was low (MAS=0, 1, and 1+), and only found significant differences when spasticity was high (MAS=2 and 3). Therefore, in patients with a mild grade of spasticity, measurement of blood pressure on the normal side is applicable. However, if the grade of spasticity is high, the impact of spasticity on the differences in blood pressure needs to be considered, especially for further treatments associated with blood pressure control, such as the dose of antihypertensive drugs.

In clinical settings, anti-spasticity medications such as baclofen and diazepam are often used in patients to reduce the grade of spasticity. However, these drugs may induce adverse reaction such as hypotension.[30] Further studies with arterial line measurements maybe required to confirm whether this decrease in blood pressure is due to reduction in spasticity. In addition, if a patient with stroke is treated with muscle relaxants, the decreased muscle tone and grade of spasticity in the arm may cause lower reading in the measurement of blood pressure. Therefore, further investigation is needed to confirm whether it is more reliable to measure blood pressure in the normal arm than in the involved arm.

There are several limitations in this study: (1)the cross-sectional design prevented observation of long-term changes in MAS score and differences in blood pressure in patients with stroke, (2)the spasticity grade of most patients selected in this study was low, and the total number of patients with high grade of spasticity was small, and (3)the interference of muscle relaxants drugs was not completely excluded from this study. Therefore, the future direction of research is to use arterial line measurements to determine whether the differences in blood pressure of normal and involved arm are due to actual differences or merely differences produced during the measurements.

CONCLUSION

This study shows that arm spasticity affects blood pressure measurements in stroke patients with severe spasticity. The inter-arm differences in blood pressure had positive correlations with spasticity. Therefore, this study suggests that a low grade of spasticity has a negligible effect on measured blood pressure values, however, the effect of a high grade of spasticity (MAS≥2) should be noted and the measured blood pressure values should be adjusted accordingly.

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上臂痙攣程度對於血壓量測的影響

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前言：過去研究指出中風病人患側上臂痙攣可能對血壓量測有影響，然而，痙攣對血壓量測如何影響結果卻不盡相同，在某些中風病患，有時無可避免需要量測病人患側手的血壓，故本研究之目的爲探討痙攣程度對於中風病人血壓量測的影響大小。

方法：蒐集 50 位桃園醫院復健科病房中風後單側無力病患。以修正版阿修伍爾斯氏痙攣量表(modified Ashworth scale)評估受試者上臂痙攣的程度，以血壓計(CSI criticare systems inc. 560DXN)量測兩側肱動脈壓。以 t 檢定比較患側與健側血壓的差異性，以變異數分析(ANOVA)檢定不同痙攣程度組間血壓變化的差異性，並用斯皮爾曼等級相關(spearman rank correlation)評估其不同痙攣程度與其平均血壓差之間的相關性。

結果：在痙攣程度較小時(修正版阿修伍爾斯氏痙攣量表= 0,1,1+)，雙側血壓無顯著差異，而痙攣程度較大時(修正版阿修伍爾斯氏痙攣量表≥2)，患側血壓較健側高，其差異達統計上顯著性。而不同痙攣程度與其對照的雙側血壓差呈正相關並達統計上的顯著性。

結論：不同的痙攣程度可能會影響到血壓量測，高痙攣(修正版阿修伍爾斯氏痙攣量表≥2)的中風病患可能使患側有較高的測量血壓值。（台灣復健醫誌 2013；41(3)：173 - 180）

關鍵詞：血壓(blood pressure)，痙攣(spasticity)，修正版阿修伍爾斯氏痙攣量表(modified Ashworth scale)

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