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ORIGINAL RESEARCH

Prevalence and Associated Risk Factors of Hypertension in Adults with Disabilities: A Cross-Sectional Study in Shanghai, China

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Background: Although hypertension is highly prevalent in China, epidemiologic data of hypertension among people with disabilities remain largely unknown. This study aims to examine the prevalence and associated risk factors of hypertension in patients with disabilities.

Methods: A cross-sectional study was carried out among 7348 adults with disabilities from February to December 2018 in Shanghai, and patient data from physical, imageological and routine blood examinations were collected and analyzed. Logistic regression models were performed to determine the associated risk factors of hypertension in adults with disabilities.

Results: Among the 7348 disabled patients, the prevalence of hypertension, rate of receiving treatment, and blood pressure control were 42.5%, 85.0% and 46.0%, respectively. Increases in the levels of age, physical disability, body mass index (BMI), fasting plasma glucose (FBG), total triglyceride (TG), hyperuricemia (hyper-UA), serum urea (SU), and estimated creatinine clearance (eCrCl <80 μmol/L) were independently correlated with hypertension.

Conclusion: Patients with physical disabilities have a significantly higher prevalence of hypertension compared to the normal population. Patients with intellectual or mental disabilities have lower rates of blood pressure control compared to other types of disabilities. Assessment of associated risk factors highlights an increased likelihood of potential renal dysfunction among hypertensive disabled patients.

Keywords: hypertension, prevalence, risk factors, adults with disabilities

Introduction

According to the latest WHO report on disability,[1] over 1 billion people worldwide – as many as 15% of the world's population, suffer from some form of disability, and approximately 110–190 million (2.2–3.8%) suffer from severe functional impairment. The disability rate in China has risen constantly in recent years due to an aging population and an increased prevalence in chronic diseases. Recent reports showed that the number of people with disabilities has reached almost 7% of the total Chinese population.[2]

Significant gaps in health disparities between people with and without disabilities have been widely demonstrated.[3,4] People living with disabilities may be more vulnerable to various chronic diseases due to limitations in physical activity in the absence of personal disability support or environmental factors. In addition, it has been established that the onset of functional disability is driven by physiological changes associated with aging and underlying chronic diseases.[5] Studies have

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demonstrated the strong associations between increased incidence of disability with chronic diseases such as hypertension, diabetes and stroke.[6,7] The onset and general pattern of incident disability among the chronically ill is often distinct from their healthy peers.[8] However, relevant data on the management of health for people with disabilities are often inadequate, especially in developing countries such as China. Therefore, the identification of health disparities in different subtypes of people with disabilities is urgently needed.

Hypertension is an independent and major risk factor for cardiovascular diseases.[7–9] The prevalence of hypertension in China has risen sharply in recent years,[10] however most studies focus on the prognosis of patients with hypertension and disease management, such as the prevention of adverse cardiovascular events. Little is known regarding the prevalence and specific risk factors of hypertension in patients with disabilities. There is a close link between disability and hypertension; however, the mechanisms by which disabilities contribute to the development of hypertension are highly varied.[11] The current clinical focus of preventing and combating hypertension in the normal population should also be extended to include people with disabilities. Therefore, in this cross-sectional study, we sought to examine the relationship between different disability features and serum indices with the risk of developing hypertension, in order to identify potential independent predictive risk factors of hypertension in adults with disabilities.

Materials and Methods

Study Population

The cross-sectional study adopted a cluster sampling to investigate the prevalence and relevant factors for hypertension in Shanghai YangZhi Rehabilitation Hospital (Shanghai Sunshine Rehabilitation Center). Shanghai YangZhi Rehabilitation Hospital (Shanghai Sunshine Rehabilitation Center) is a designated medical and health care institution for the disabled by the Shanghai Disabled Persons' Federation that provided free yearly health examination services. From February 2018 to December 2018, a total of 8137 subjects with disabilities were collected and underwent a professional medical and functional assessment by designated physicians to identify type and severity of the disability. According to the classification and grading criteria of disability (GB/T 26341–2010)[12] and the International Classification of Functioning, Disability and Health (ICF), disability is defined as one or more abnormalities in anatomical structure or the loss of a particular organ or function that significantly impacts the daily life of a given individual. Health examinations are conducted voluntarily including physical, imaging, and laboratory examinations. Subjects with incomplete medical examination records or aged less than 18 years were excluded from subsequent analyses. Finally, a total of 7348 disabled patients were involved in the final study (52.5% males, average age 60.1±11.1 years).

Measurements

For blood pressure (BP) measurement, most of the participants were examined in the sitting position after resting for approximately 10 min. BP was recorded twice by a trained physician using automatic arm blood pressure monitors (Omron Corp., Tokyo, Japan), with two readings obtained 30 seconds apart. For those with missing upper limbs or trauma, the measurements of leg blood pressure in lying posture were conducted. Generally, the physicians measured BP in both limbs (ankle – posterior tibial artery) and the limb with the highest reading was used. There were a total of 23 participants in the current study who underwent leg blood pressure measurement. Therefore, we converted the leg blood pressure value according to the recommendation of literatures[13,14] in order to make it consistent with arm blood pressure. Body mass index (BMI) was calculated based on weight (kg)/(height (m)^2). Subjects who were unable to stand on their feet had their height measured in a supine position with the help of the observers. For subjects with mobility problems, height records were based on their self-report.

Laboratory tests include the following: fasting plasma glucose (FBG), total cholesterol (TC), total triglyceride (TG), albumin (Alb), globulin (Glo), uric acid (UA), serum creatinine (SCr), serum urea (SU), hemoglobin (Hb), red blood count (RBC), white blood count (WBC), and platelet count (PLT) were collected for each patient during medical examination. Routine blood examination was performed in the morning after an overnight fasting period of at least 12 h. Serum indices including FBG, TC, TG, Alb, Glo, UA, CR, SU, Hb, RBC, WBC, and PLT were measured enzymatically (Roche Corporation, Basel, Switzerland). Estimated creatinine clearance (eCrCl) was calculated based on the Cockcroft and Gault equation as follows:

$$eCrCl = \frac{(140 - Age) \times Weight[kg](\times 0.85\ if\ woman)}{72 \times (Scr[\mu\ mol/L]/88.4)}$$

Note: 88.4 is a conversion factor used to express SCr in mg/dL.

Definitions

Prevalence of hypertension, diabetes mellitus (DM), hyperlipidemia (HPL), and coronary heart disease (CHD) was verified by clinical examinations. Prevalence of hypertension was defined as having a history of hypertension, or mean systolic blood pressure (SBP) ≥140mm Hg or mean diastolic blood pressure (DBP) ≥90mm Hg.[15] Prevalence of DM was defined as having a history of DM, or FBG ≥7.0 mmol/L.[16] Prevalence of HPL was defined as having a history of HPL, or TC ≥5.2 mmol/L or TG ≥1.7 mmol/L.[17] Prevalence of CHD was defined as having a history of CHD, or doctor's diagnosis via imageological examination.

Participants who were taking antihypertensive drugs were considered to be under treatment. Blood pressure control was defined based on the guidelines from the Eighth Joint National Committee (JNC 8), where a BP <140/90 mm Hg for CKD patients was recommended. Uncontrolled blood pressure was defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg.

According to the Chinese classification and grading criteria of disabilities,[12] the types of disabilities included physical disability, intellectual/mental disability, vision disability, hearing/speech disability, or multiple disabilities. The degree of disability was classified and graded as very severe disability, severe disability, moderate disability, or mild disability.

Statistical Analysis

All study data were analyzed using IBM SPSS 24.0 software (IBM Corp., Armonk, New York, USA). Continuous variables were described as mean ± SD (normal distribution) and as medians with interquartile range (skewed distribution), and subsequent independent samples *T*-test and Mann–Whitney *U*-test were performed, respectively. Categorical variables were summarized as percentages, and the Chi-square test was used for comparisons between groups. Univariate and multivariate logistic regressions were selected to evaluate the potential association with hypertension in the newly categorical variables. Covariates included in the multivariable logistic regression models included age, gender (male vs female), physical disability (non-physical disability vs physical disability), degree of disability (very severe disability vs severe disability vs moderate disability vs mild disability), hyperuricemia (>422 μmol/L for men, >363 μmol/L for women), eCrCl (<80 μmol/L vs ≥80 μmol/L), BMI, FBG, TG and SU. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported.

Results

Among the 7348 disabled patients included in the study, the average age was 60.1±11.1 years old, including 3861 (52.5%) men and 3487 (47.5%) women. Overall, the prevalence of hypertension among all disabled patients was 42.5%. The prevalence of hypertension was increased significantly in older patients. Among the patients with hypertension, the rate of those undergoing hypertensive treatment and those who were able to control their blood pressures were 85.0% and 46.0%, respectively. There were statistically significant differences in the prevalence of hypertension among different age groups. There were statistically significant differences in the prevalence of hypertension between males and females, regardless of age (Table 1). The rate of hypertension treatment and control decreased in male patients, as well as those in the lowest age group (18–39 years). Patients with intellectual/mental disabilities were less likely to receive antihypertensive treatment and had lower ability to control their blood pressure than those with other types of disabilities. There were no differences in the

Table 1 Prevalence of Hypertension Stratified by Age and Gender

Age Group	Total (n=7348)		Male (n=3861)		Female (n=3487)	
	No.	Prevalence	No.	Prevalence	No.	Prevalence
18–39	50	8.9%	30	10.0%	20	7.6%
40–59	779	31.9%	432	37.9%	347	26.7%
60–79	2227	52.5%	1291	54.8%	936	49.6%
≥80	67	64.4%	38	57.6%	29	76.3%
Total	3123	42.5%	1791	46.4%	1332	38.2%

Table 2 Hypertension Treatment and Control Rates of Participants

Variables	Treatment		Control	
	Cases n (%)	**(% 95% CI)**	**Cases n (%)**	**(% 95% CI)**
Total (n=3123)	2653 (85.0)	(83.7–86.3%)	1437 (46.0)	(44.3–47.7%)
Gender				
Male (n=1791)	1137(63.5)	(61.3–65.7%)	832 (46.5)	(44.2–48.8%)
Female (n=1332)	1116 (83.8)	(81.8–85.8%)	605 (54.2)	(51.5–56.9%)
Age				
18–39 (n=50)	31 (62.0)	(48.5–75.5%)	17 (34.0)	(20.9–47.1%)
40–59 (n=779)	649 (83.3)	(80.7–85.9%)	395 (50.7)	(47.2–54.2%)
60–79 (n=2227)	1911 (85.8)	(84.4–87.2%)	1001 (45.0)	(42.9–47.1%)
≥80 (n=67)	62 (92.5)	(86.2–98.8%)	24 (35.8)	(24.3–47.3%)
Type of disability				
Physical disability (n=1939)	1708 (88.1)	(86.7–89.5%)	918 (47.3)	(45.1–49.5%)
Intellectual/Mental disability (n=281)	194 (69.0)	(63.6–74.4%)	87 (31.0)	(25.6–36.4%)
Vision disability (n=681)	574 (84.3)	(81.6–87.0%)	338 (49.6)	(45.8–53.4%)
Hearing/Speech disability (n=182)	145 (79.7)	(73.9–85.5%)	84 (46.2)	(39.0–53.4%)
Multiple disability (n=40)	22 (55.0)	(39.6–70.4%)	11 (27.5)	(13.7–41.3%)
Degree of disability				
Very severe disability (n=213)	178 (83.6)	(78.6–88.6%)	106 (49.8)	(43.1–56.5%)
Severe disability (n=411)	354 (86.1)	(82.8–89.4%)	192 (46.7)	(41.9–51.5%)
Moderate disability (n=1032)	872 (84.5)	(82.3–86.7%)	483 (46.8)	(43.8–49.8%)
Mild disability (n=1467)	1249 (85.1)	(83.3–86.9%)	656 (44.7)	(42.2–47.2%)

hypertension treatment and control rates among different degree of disability (Table 2).

The demographic and clinical features of subjects are summarized in Table 3. The prevalence of hypertension was highest in those with physical disability (47.5%) and lowest in those with intellectual/mental disability (24.9%). Patients with hypertension also had a higher rate of DM (18.9%), HPL (31.4%) and CHD (13.6%), as well as levels of BMI, FBG, TG, Glo, UA, SCr, SU, RBC, and WBC compared to those with normotension.

Variables that differed significantly between groups were subsequently entered into logistic regression models to assess the potential risk factors correlated with hypertension. As displayed in Table 4, age, gender, physical disability, degree of disability, BMI, FBG, Glo, UA, eCrCl, SU, RBC and WBC were significantly correlated to hypertension based on univariate logistic regression analysis. Furthermore, age (per 1 year) [OR: 1.06 (95% CI: 1.06–1.07)], male gender [OR: 1.19 (95% CI: 1.04–1.37)], physical disability [OR: 1.31 (95% CI: 1.17–1.46)], BMI [OR: 1.16 (95% CI: 1.14–1.18)], FBG [OR: 1.13 (95% CI: 1.10–1.17)], TG [OR: 1.06 (95% CI: 1.02–1.10)], SU [OR: 1.09 (95% CI: 1.05–1.14)], hyper-UA [OR: 1.43 (95% CI: 1.29–1.63)] and eCrCl <80μmol/L [OR: 1.05 (95% CI: 1.01–1.20)] significantly increased the risk of hypertension (Table 5).

Categorical variables were shown as the number of disabled patients (column percentage). Normal distribution parameters (BMI, SBP, DBP, FBG, TC, Alb, Glo, Hb, RBC, WBC, PLT) were presented as the mean (SD); skewed distribution parameters were expressed as median (quartiles).

Discussion

Hypertension is a common comorbidity that is becoming more prevalent worldwide, especially in disabled people who have limited capacity for self-care. In the current study, we demonstrated that the prevalence of hypertension among people with disabilities, as well as the rate of those undergoing treatment or were able to control their blood pressures, were significantly varied according to different demographics and disability-specific characteristics. In addition, increases in the level of age, body mass index (BMI), fasting plasma glucose (FBG), total triglyceride (TG), uric acid, creatinine, and serum urea were shown to be closely correlated with an increased risk of

Table 3 Distribution of Socio-Demographic and Clinical Characteristics of Disabled Persons by Hypertension Status (Normotension vs Hypertension)

Variables	Normotension (n=4225)	Hypertension (n=3123)
Age, mean (SD), years	57.1 (12.0)	64.2 (8.4)
Male, %	49.0	57.3
Types of disability, % (95% CI)		
Physical disability	50.7 (49.2–52.2)	62.1 (60.4–63.8)
Intellectual/Mental disability	20.1 (18.9–21.3)	9.0 (8.0–10.0)
Vision disability	20.3 (19.1–21.5)	21.8 (20.4–23.2)
Hearing/Speech disability	7.6 (6.8–8.4)	5.8 (5.0–6.6)
Multiple disability	1.4 (1.0–1.8)	1.3 (0.9–1.7)
Degree of disability, % (95% CI)		
Very severe disability	8.2 (7.4–9.0)	6.8 (5.9–7.7)
Severe disability	15.7 (14.6–16.8)	13.2 (12.0–14.4)
Moderate disability	33.1 (31.7–34.5)	33.0 (31.4–34.6)
Mild disability	42.9 (41.4–44.4)	47.0 (45.2–48.8)
Education level, % (95% CI)		
Illiterate	3.0 (2.5–3.5)	2.6 (2.0–3.2)
Primary school	17.5 (16.4–18.6)	19.2 (17.8–20.6)
Junior high school	53.3 (51.8–54.8)	55.2 (53.5–56.9)
Senior high school or higher	26.2 (24.9–27.5)	23.0 (21.5–24.5)
Prevalence of disease, % (95% CI)		
Diabetes mellitus	8.5 (7.7–9.3)	18.9 (17.5–20.3)
Hyperlipidemia	23.7 (22.4–25.0)	31.4 (29.8–33.0)
Coronary heart disease	5.8 (5.1–6.5)	13.6 (12.4–14.8)
BMI, mean (SD), kg/m^2	23.7 (3.5)	25.4 (3.5)
SBP, mean (SD), mmHg	120.0 (12.4)	136.2 (15.9)
DBP, mean (SD), mmHg	73.2 (7.6)	79.5 (8.4)
FBG, mean (SD), mmol/L	5.4 (1.5)	6.0 (1.9)
TC, mean (SD), mmol/L	5.1 (1.0)	5.1 (1.0)
TG, median (quartiles), mmol/L	1.3 (0.9, 1.9)	1.5 (1.1, 2.2)
Alb, mean (SD), g/L	43.9 (2.4)	43.8 (2.4)
Glo, mean (SD), g/L	30.0 (3.9)	30.3 (4.0)
UA, median (quartiles), mol/L	304.6 (254.6, 357.9)	333.2 (279.4, 390.9)
SCr, median (quartiles), μmol/L	59.4 (49.7, 70.0)	63.4 (52.3, 75.0)
eCrCl, median (quartiles), mL/min	95.6 (78.7, 116.6)	90.0 (74.3, 110.6)
SU, median (quartiles), mmol/L	5.0 (4.0, 6.0)	5.0 (4.0, 6.0)
Hb, mean (SD), g/L	141.4(15.4)	142.5 (14.8)
RBC, mean (SD), 10^{12}/L	4.7(0.5)	4.7 (0.5)
WBC, mean (SD), 10^9/L	6.5 (1.8)	6.7 (1.7)
PLT, mean (SD), 10^9/L	225.5 (62.5)	226.7 (61.1)

Table 4 Related Factors of Hypertension from Univariate Logistic Regression

Variables	OR	95% CI
Age (per 1 year)	1.07	1.07–1.08
Gender (male)	1.40	1.28–1.56
Physical disability	1.59	1.45–1.75
Degree of disability		
Mild disability	–	–
Moderate disability	0.76	0.63–0.92
Severe disability	0.76	0.66–0.88
Very severe disability	0.91	0.82–1.01
BMI	1.15	1.14–1.17
FBG	1.21	1.18–1.25
TG	1.19	1.15–1.24
SU	1.24	1.20–1.28
RBC	1.17	1.06–1.29
WBC	1.10	1.07–1.13
Glo	1.01	0.99–1.28
hyper-UA	1.89	1.67–2.14
eCrCl <80 μmol/L	1.46	1.32–1.61

Table 5 Adjusted OR for Related Factors of Hypertension from Multivariate Logistic Regression

Variables*	OR	95% CI
Age (per 1 year)	1.06	1.05–1.07
Gender (male)	1.19	1.04–1.37
Physical disability	1.31	1.17–1.46
BMI	1.16	1.14–1.18
FBG	1.13	1.10–1.17
TG	1.06	1.02–1.10
SU	1.09	1.05–1.14
hyper-UA	1.43	1.24–1.63
eCrCl <80 μmol/L	1.05	1.01–1.20

Notes: *Adjust variables included of age, gender, physical disability, BMI, FBG, TG, SU, hyper-UA, eCrCl.

hypertension. Compared with the national survey of hypertension in China,[18] our study showed that the prevalence of hypertension in disabled subjects, as well as the rate of those undergoing hypertensive treatment or were controlling their blood pressures were significantly higher than that of the general population. Due to the presence of patients with mental disorders, we did not evaluate the rate of hypertension self-awareness. The higher treatment and control rates of blood pressure in disabled patients may in part be explained by the increased frequency of screening and diagnosis. Disabled people who were young and male were less likely to receive treatment or have control for hypertension.

Interestingly, our results revealed that people with physical disabilities had higher rates of hypertension than other types of disabilities, and were a major determinant of hypertension even after adjusting for demographic variables. Studies have shown that people with physical disabilities were more likely to have comorbidity with chronic diseases than their able-bodied counterparts.[19] A possible reason lies in the fact that people with physical disabilities are more severely affected by their physiological deficiencies and environmental factors when compared to subjects with any other single disability. Except for the impact of being physically inactive,[20] which is a main risk factor for hypertension itself, physically disabled people are more vulnerable against psychological stress and discrimination, especially for those with spinal cord injury.[21] A previous study has suggested that physically disabled people may receive less benefits from the rehabilitation and healthcare services.[3] This may also contribute to a higher risk of hypertension among people with physical disabilities. However, there is limited data on whether limb deficiency has any direct impact on peripheral blood pressure. We found that subjects with intellectual or mental disabilities have relatively lower rates of hypertension. This may be related to two main factors. Firstly, hypertension was determined based on blood pressure measurements and subjects' medical records in our current study. Due to the lack of self-care knowledge and ability in detecting disease, the actual prevalence of hypertension among people with intellectual or mental disabilities may be underestimated. Secondly, we ascribed the potential reason to psychological factors. It has been reported that people with intellectual or mental disability usually perceive less psychological distress and stress than other types of disabilities.[22] Further studies are needed to better understand the differences in blood pressure monitoring between normal and disabled populations, as well as the underlying physiological or psychological mechanisms involved in the development of hypertension.

Hypertension has been closely linked to numerous risk factors such as increased age, male gender, being overweight or obese, and excessive salt consumption in the general population.[23,24] Consistent with previous studies, our multivariate logistic regression model showed significant correlations between hypertension and age, BMI, FBG, and TG.

Furthermore, our study showed that in adults with disabilities, hyper-UA, SU, and eCrCl <80 μmol/L all increased the risk of hypertension. Elevated UA has been closely associated with the risk of cardiovascular diseases and hypertension,[25–27] eliciting immune responses in arterial hypertension and renal diseases,[28,29] and promoting vasoconstriction and vasodilatation.[30,31] Renal dysfunction is highly prevalent in essential hypertension, while creatinine clearance rate is a sensitive indicator for renal function and is highly predictive of poor cardiovascular outcomes and all-cause death in adults with hypertension. Our study demonstrated that eCrCl <80 μmol/L had significant correlation with hypertension in the disabled population. Combined with the abnormal levels of uric acid and urea, we speculated that disabled people with hypertension may have a higher proportion of renal impairment. Since the rate of blood pressure control was similar in disabled patients compared to the general population, the occurrence of renal dysfunction may be due to the occurrence of multiple chronic comorbidities and associated drug misuse. Thus, the current management strategy for hypertensive patients needs improvement in order to account for people who are at risk of renal dysfunction.

Several limitations of our study should be considered. As a cross-sectional study, our research merely offered a statistical relationship between the risk factors and hypertension among disabled people. The study results could not determine a cause-effect association, and potentially unknown influencing factors could not be excluded. In order to avoid self-reported bias of information, we did not analyze the effects of anti-hypertensive drugs. We were also unable to assess the lifestyle aspects of the disabled patients due to the lack of original data. Further retrospective or prospective cohort studies should be performed to better understand the effects of hypertension in patients with disabilities.

Conclusions

This study provides important new information regarding the demographics and disability-specific characteristics associated with hypertension in the disabled population. In particular, more attention should be paid to subjects with physical disabilities in primary hypertension screening and management. Assessment of associated risk factors suggests an association between elevated eCrCl and hypertension among disabled people. We highlight an increased likelihood of renal dysfunction among hypertensive disabled patients. Further cohort study is warranted to verify the association between BP control and the clinical diagnosis of kidney disease. Overall, improvements in hypertension management among people with disabilities may require a targeted approach that incorporates both demographical and clinical characteristics.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Informed Consent

This study was in accordance with the principles of Helsinki Declaration and approved by the ethics committee of Shanghai YangZhi Rehabilitation Hospital (Shanghai Sunshine Rehabilitation Center), School of Medicine, Tongji University (Approval number: YZ2019-051). The subjects and all health information in this study are derived from the free yearly health examination services. Study subjects and their primary caregivers are aware of and voluntarily participate in these health examinations. Therefore, the declaration of informed consent was not required by the ethics committee. Data confidentiality was guaranteed.

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Disclosure

The authors declare that they have no competing interests.

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