Original Article

Association between post-traumatic stress disorder and hypertension in Congolese exposed to violence: a case–control study

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Background: Numerous risk factors have been involved in the pathogenesis of hypertension. The contribution of psychological factors, including post-traumatic stress disorder, remains largely underexplored, despite their potential role in hypertension.

Objectives: We compared the prevalence of trauma, post-traumatic stress and other psychological disorders between hypertensive and normotensive patients from Bukavu (Democratic Republic of Congo), a 25-year war-exposed city.

Methods and measures: In this case–control study, we assessed past traumatic events with the Stressful-Events-Scale, post-traumatic stress disorder through the post-traumatic diagnostic scale, depression and alcohol use disorder through the MINI-International-Neuropsychiatric-Interview, and emotion regulation through the Emotion-Regulation-Questionnaire in 106 hypertensive and 106 normotensive patients, enrolled at the Bukavu General Hospital.

Results: Compared with normotensive controls (73% women, age: 43 ± 14 years, BP: $121 \pm 10/75 \pm 8$ mmHg), hypertensive patients (57% women, age: 42 ± 13 years, BP: $141 \pm 12/82 \pm 7$ mmHg, on a median of two antihypertensive drugs) were exposed to more man-made traumas (61 vs. 13%, $P < 0.001$), used more expressive suppression ($P = 0.05$) and less cognitive reappraisal ($P = 0.02$) as emotional regulation strategies. They developed more frequent post-traumatic stress disorder (36 vs. 7%, $P < 0.001$) and major depressive disorder (37 vs. 13%, $P = 0.001$), often in association with alcohol use disorder (23 vs. 4%, $P < 0.001$). In multivariate logistic regression, post-traumatic stress disorder [OR = 3.52 (1.23–6.54)], man-made trauma [OR = 2.24 (1.15–4.12)], family history of hypertension [OR = 2.24 (1.06–4.44)], fasting blood glucose [OR = 1.85 (1.07–3.08)], BMI [OR = 1.28 (1.12–2.92)], expressive suppression [OR = 1.23 (1.11–2.23)] and cognitive reappraisal [OR = 0.76 (0.63–0.98)] were independent predictors of hypertension.

Conclusion: In Congolese populations exposed to war, man-made trauma exposure and post-traumatic stress disorder appear to be more tightly related to hypertension than classical hypertension risk factors.

Keywords: Africa, Democratic Republic of Congo, hypertension, post-traumatic stress disorder, risk factors, trauma

Abbreviations: BP, blood pressure; PTSD, post-traumatic stress disorder

INTRODUCTION

Arterial hypertension is among the leading causes of morbidity and mortality worldwide. According to the last global estimates in 2010, the number of people presenting high blood pressure was as high as 1.39 billion, representing 31.1% of the global adult population [1]. When not managed properly, arterial hypertension predisposes to deadly or disabling complications, such as stroke, myocardial infarction, heart and renal failure, retinopathy and hypertensive encephalopathy. In 2015, the number of deaths associated with hypertension was 7.8 million (14% of all deaths worldwide) [2]. These alarming numbers explain the interest of clinicians and researchers in identifying risk factors and proposing efficient preventive

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measures. Classical modifiable risk factors, such as excessive sodium consumption, insufficient dietary potassium, overweight and obesity, high alcohol intake and physical inactivity have long been established [3]. However, hypertension is a complex condition where genetic, physiologic and psychosocial factors interact.

Beyond lifestyle and environmental risk factors, some evidence supports the existence of an association between psychological factors, in particular post-traumatic stress disorder (PTSD), and hypertension [4–10]. Along the same lines, a number of studies reported an association between emotion expression/suppression and high blood pressure [11–17]. Depression and alcohol use disorder have also been consistently associated to hypertension [18–22] and are highly comorbid with PTSD [23–26]. The association between PTSD and hypertension was mostly observed in individuals exposed to repetitive traumatic experiences, such as military veterans [7], or other populations presenting PTSD [5]. When studying general medical populations in high-income countries, the association of hypertension with PTSD and psychological factors was mostly reported in patients with severe, drug-resistant hypertension [27].

Hence, the importance of psychological/traumatic factors is often considered a marginal factor accounting for hypertension in a limited number of patients, whereas hypertension is widely considered to be mostly related to abnormal lifestyle, environmental and genetic factors, as described above.

Currently, no study has assessed the association between PTSD and hypertension in low-income and middle-income countries, where 75% of people with hypertension (1.04 billion) live [1] and where most of the armed conflicts, known to generate high PTSD rates, take place. Therefore, in such armed conflict countries, it is relevant to assess the importance of trauma and other psychological factors in hypertensive patients at large, and to compare the importance of these psychological factors to that of more conventional metabolic and lifestyle-related factors.

The Eastern Democratic Republic of Congo has been undergoing more than two decades of war and armed conflicts, which resulted in more than 5.4 million deaths [28]. As a result, the prevalence of psychiatric conditions is very high in the general population, with estimates as high as 50% for PTSD and 41% for depression [29]. Together with these psychological consequences, the prevalence of hypertension has also increased considerably during the last decades, reaching 41% in urban populations and 38% in rural ones [30]. Yet, at the beginning of the 20th century, hypertension was reported to be extremely rare in sub-Saharan Africa [31]. Many factors, such as age, gender, obesity, diabetes, diet, physical activity and marital status appear associated with hypertension in the Eastern Democratic Republic of Congo [32]. However, the potential impact of trauma related to armed conflicts remains to be investigated as a determinant of hypertension within these populations.

Our objective was to measure concomitantly classical risk factors of hypertension, exposure to traumatic events, post-traumatic stress and other psychological disorders in patients with and without hypertension consulting at the General Hospital of Bukavu (Democratic Republic of Congo), a city affected by war for the last 25 years, and to assess their association with hypertension.

PATIENTS AND METHODS

We conducted this hospital-based, case–control study in a tertiary referral hospital in the city of Bukavu between January 2018 and December 2019. Our sampling frame consisted of all patients attending the outpatient clinic of internal medicine during the study period. Among them, only those who met the inclusion criteria as either a case or control were included in the analysis. Cases were patients who had already a diagnosis of hypertension according to the European Society of Cardiology (ESC)/European Society of Hypertension (ESH) definition [33] and/or were already on antihypertensive medication(s). Hypertension was defined as office SBP values at least 140 mmHg and/or DBP values at least 90 mmHg at repeated BP measurements on different occasions [33]. Controls were patients attending the same outpatient clinic with no current or past hypertension. In the control group, 62% of patients were suffering from infectious diseases, 21% from digestive symptoms, 10% from rheumatic diseases and 7% from neurological diseases. All patients aged more than 18 years old, whose medical file included routine blood parameters and who accepted to sign the informed consent were included in the study. Exclusion criteria were secondary hypertension for cases, and high blood pressure (SBP $\geq$140 mmHg and/or DBP $\geq$90 mmHg) at the time of inclusion for controls.

Data were collected by five medical students using a structured questionnaire. The principal investigator (A.B.) trained the medical students over 3 days, emphasizing the theoretical and practical aspects of all questions in the questionnaire, informed consent and participant confidentiality.

Ethics

The study protocol was approved by the Ethics Committee of the Catholic University of Bukavu and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants, both hypertensive and normotensive, and privacy and confidentiality of the participants were ensured. Participants found to have mental troubles were advised to seek appropriate care at the psychiatric department of Bukavu Regional Referral Hospital.

Measures

A locally generated questionnaire was used to collect sociodemographic data including age, sex, marital status, tribe and profession. The questionnaire also assessed family history of hypertension (i.e. hypertension diagnosed before the age of 50 years in first-grade relatives), the presence of type 2 diabetes (defined as fasting blood glucose $\geq$126 mg/dl or antidiabetic treatment) and the number and nature of hypertensive drugs.

Anthropometric (e.g. body weight, height, waist circumstance) and biochemical parameters (e.g. fasting plasma glucose, HDL-cholesterol, LDL-cholesterol, triglycerides) were extracted from patients' medical file and considered

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if the sample was collected less than 3 months before enrolment in the study.

Blood pressure measurement

The five research assistants measured the participants' blood pressure (BP) at the internal medicine consultation using a validated Omron HEM-907 digital monitor [34]. Before measuring BP, we made sure that participants did not consume caffeine, did not smoke, or did not perform heavy physical activities 30 min before BP measurement. Participants rested for at least 5 min before the measurement in a sitting position, with the arm supported at heart level. Patients were taking antihypertensive drugs as prescribed. The analyses were performed on the mean of three consecutive measurements.

Psychological assessment

We assessed depression and alcohol use disorder using the French version of the MINI International Neuropsychiatric Interview 7(MINI), a structured diagnostic interview compatible with the *Diagnostic and Statistical Manual of Mental Disorders* [35] with established validity and reliability in different populations in USA, Uganda, Brazil, Japan and Europe [36–38]. The MINI determines the presence or absence of psychiatric disorders according to the core and secondary symptoms described by the DSM-5. We measured past traumatic events and PTSD through the Post-traumatic diagnostic Scale – French adaptation (PDS-F), along with a Stressful Events Scale [39], a detailed scale assessing the types and magnitude of a wide variety of traumatic events as well as PTSD symptoms. The traumatic events in this study have been grouped in man-made traumatic events (e.g. physical assault, sexual assault, experience of combat, victim of hostage-taking or kidnapping) and nonman-made traumatic events (e.g. accident, environmental disaster, animal aggression, serious health problem, death of a relative) (Supplementary Table S1, http://links.lww.com/HJH/B816). This scale showed good psychometric values in African populations [40] and has a validated French version [39]. The PDS-F is interpreted with a severity score ranging from 0 to 51 obtained by adding up responses of items. For the diagnosis of PTSD to be made, we considered the cut off for moderate-to-severe symptoms, rating more than 20 [41]. The Emotion Regulation Questionnaire assessed two emotion regulation's constructs: cognitive reappraisal (i.e. changing the way one thinks about potentially emotion-eliciting events) and expressive suppression (i.e. intentional reduction of expression of an emotion) [42] and we used a validated French version [43]. Previous studies indicate that cognitive reappraisal is an adaptive regulation of emotion strategy associated with well-being while expressive suppression is a maladaptive one associated with affective impairment [44,45].

Data analysis

We analysed data using Stata Version 13 to perform descriptive and inferential analysis. Qualitative variables were described in term of frequencies and percentages while continuous variables were described in term of means ± standard deviation. Pearson chi^2 and Student *t*-test were used to compare characteristics of patients for respectively categorical and continuous variables. We used bivariate and multiple logistic regression to identify demographic, medical and psychological variables associated to hypertension using the individual odds ratio [95% confidence intervals (CI)]. The associations were deemed significant with a P value less than or equal to 0.05. Variables were included in multiple regression when they were associated with hypertension at a P value 0.05 or less.

RESULTS

Demographic and clinical characteristics of hypertensive patients and normotensive controls

During the inclusion period, 221 patients were found to be eligible. Nine patients (five hypertensive patients and four normotensive controls) declined participation. Therefore, 212 participants were included in subsequent analysis, among which 106 had arterial hypertension (57% women; mean age: 42.5 ± 13.6 years;) and 106 were normotensive in the absence of antihypertensive treatment (78% women; mean age: 42.6 ± 14.6 years). All patients with hypertension were on treatment (median number of drugs 2; IQR = 1). Hypertensive and normotensive patients did not differ regarding age ($P = 0.42$), gender ($P = 0.23$) and marital status (0.43) but patients with hypertension presented a

TABLE 1. Demographic and clinical characteristics of hypertensive patients versus normotensive controls

Variables	Total ($n = 212$)	Hypertension ($n = 106$)	Normotension ($n = 106$)	P value
Age (years)	42.5 ± 13.6	42.4 ± 13.5	42.6 ± 14.6	0.42
Women (%)	143 (67)	60 (57)	83 (78)	0.23
Married (%)	110 (52)	48 (45)	62 (58)	0.43
SBP (mmHg)	131 ± 15	141 ± 12	121 ± 10	<0.001
DBP (mmHg)	79 ± 8	82 ± 7	75 ± 8	<0.001
BMI (kg/m^2)	23.5 ± 3.63	24.5 ± 3.51	22.6 ± 3.48	0.05
Type 2 diabetes (%)	29 (14)	20 (18)	9 (9)	0.04
Fasting plasma glucose (mg/dl)	91 ± 13	95 ± 16	86 ± 9	0.001
Total cholesterol (mg/dl)	194 ± 36	200 ± 41	187 ± 29	0.06
High-density lipoprotein (HDL) cholesterol	42 ± 9	43 ± 10	41 ± 9	0.29
Low-density lipoprotein (LDL) cholesterol	142 ± 25	152 ± 27	132 ± 25	0.63
Family history of hypertension (%)	128 (61)	79 (74)	49 (46)	0.05

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TABLE 2. Psychological parameters in hypertensive patients versus normotensive controls

Variables	Total	Hypertension	Normotension	*P* value
Frequency of trauma event (How often did the event occur?)	9.76 ± 3.30	11.15 ± 3.39	8.38 ± 2.64	<0.001
Intensity of trauma event (How stressful was the event?)	37.76 ± 14.87	46.00 ± 14.56	29.53 ± 10.25	<0.001
Man-made trauma (%)	78 (37)	65 (61)	13 (12)	<0.001
Nonman-made trauma (%)	66 (31)	39 (36)	27 (25)	0.12
Expressive suppression	4.39 ± 1.34	5.63 ± 1.55	3.15 ± 1.21	0.02
Cognitive reappraisal	3.53 ± 1.53	2.95 ± 1.48	4.12 ± 1.64	0.05
PTSD (%)	42 (19)	36 (33)	6 (7)	<0.001
Alcohol use disorder (%)	28 (13)	24 (23)	4 (4)	<0.001
Depression (%)	53 (25)	39 (37)	14 (13)	0.001
At least one psychiatric disorder (PTSD, depression or alcohol use disorder) (%)	68 (32)	43 (45)	25 (23)	<0.001

PTSD, post-traumatic stress disorder.

higher BMI ($P = 0.05$), and fasting plasma glucose ($P = 0.001$) (Table 1).

Psychological and social parameters of participants

When compared to normotensive individuals, patients with hypertension scored higher to both frequency of traumatic events ($P < 0.001$), particularly man-made traumatic events ($P < 0.001$) and intensity of stress related to traumatic events. They were more likely to suffer from PTSD ($P < 0.001$), depression ($P = 0.001$) and alcohol use disorder ($P < 0.001$). Finally, regarding emotion regulation, patients with hypertension were more likely to use expressive suppression ($P = 0.05$) and less likely to use cognitive reappraisal ($P = 0.02$) (Table 2).

Factors associated with hypertension

Univariate and multivariate analyses assessed the association between demographic, medical, psychosocial parameters and hypertension. Most importantly, in univariate analysis, the odds of having PTSD was 10 times higher in patients with hypertension compared with normotensive controls. In multivariate analysis, PTSD [OR = 3.52 (1.23–6.54)] remained a strong independent predictor of hypertension, followed by man-made trauma [OR = 2.24 (1.15–4.12)], family history of hypertension [OR = 2.24 (1.06–4.44)], fasting blood glucose [OR = 1.85 (1.07–3.08)], BMI [OR = 1.28 (1.12–2.92)], expressive suppression of emotions [OR = 1.23 (1.11–2.23)] and cognitive reappraisal [OR = 0.76 (0.63–0.98)], which were all independently associated with hypertension (Table 3).

Factors associated with blood pressure control among hypertensive patients

Fifty-four percent of hypertensive patients ($n = 57$) were controlled on antihypertensive treatment, whereas 46% ($n = 49$) were not. On an exploratory basis, we compared demographic, medical and psychological characteristics of controlled vs. uncontrolled hypertensive patients (Supplementary Tables S2 and S3, http://links.lww.com/HJH/B816). Uncontrolled hypertensive patients differed from controlled patients by a higher level of plasma glucose ($P = 0.03$), a higher rate of man-made trauma ($P = 0.003$), alcohol-use disorder and psychiatric disorder of any kind ($P = 0.001$ for both). Furthermore, patients whose BP remained uncontrolled on treatment tended to present more often hallmarks of PTSD ($P = 0.09$).

DISCUSSION

Our study is the first to assess concomitantly classical risk factors of hypertension, exposure to trauma, psychiatric disorders and emotion regulation strategies in a series of hypertensive and normotensive patients consulting in internal medicine in a postconflict sub-Saharan country. The main results are that, when compared with normotensive patients, patients with hypertension presented a higher exposure to man-made traumatic events, a higher rate of PTSD and to a lower extent, a more frequent family history

TABLE 3. Univariate and multivariate logistic regression of factors associated to hypertension

Factors associated with hypertension	Univariate OR (95% CI)	*P* value	Adjusted OR (95% CI)	*P* value
BMI	1.18 (1.05–1.33)	0.005	1.28 (1.12–2.92)	0.04
Fasting plasma glucose	1.06 (1.02–1.10)	0.003	1.85 (1.07–3.08)	0.04
Family history of hypertension	3.4 (1.04–4.45)	0.05	2.24 (1.06–4.44)	0.05
Man-made trauma	2.74 (1.98–9.06)	<0.001	2.24 (1.15–4.12)	0.03
Frequency of trauma event	1.34 (1.15–1.56)	<0.001	0.79 (0.55–1.77)	0.41
Intensity of trauma event	1.10 (1.06–1.15)	<0.001	1.28 (0.92–1.20)	0.37
Cognitive reappraisal	0.64 (0.42–0.87)	0.05	0.76 (0.63–0.98)	0.05
Expressive suppression	2.03 (1.02–2.04)	0.02	1.23 (1.11–2.23)	0.04
PTSD	10.39 (3.88–27.78)	0.018	3.52 (1.23–6.54)	0.04
Depression	3.93 (1.71–9.03)	0.001	1.11 (0.44–8.55)	0.63
Alcohol use disorder	5.60 (2.04–15.36)	0.001	1.76 (0.87–3.95)	0.18

CI, confidence interval; OR, odd ratio; PTSD, post-traumatic stress disorder.

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of hypertension, higher blood glucose concentrations and higher BMI. Within the hypertensive group, patients whose blood pressure was uncontrolled on antihypertensive treatment had also experienced a higher proportion of man-made trauma compared with controlled patients, and tended to show more often hallmarks of PTSD.

The observation that hypertensive patients report more frequently a family history of hypertension, have a higher fasting plasma glucose and BMI and suffer more often from type 2 diabetes was expected. Notably, in the South Kivu region, high blood pressure has been associated with BMI and increased waist circumference [32]. While obesity is directly involved in the pathophysiology of hypertension, the association between diabetes and hypertension may result from an overlap in cause and mechanisms, with common pathways, such as overweight, insulin resistance, inflammation and oxidative stress [46,47].

Interestingly, above and beyond these common family and metabolic factors, patients with hypertension presented higher levels of trauma exposure and PTSD than controls. This association with PTSD is in agreement with previous studies performed in the United States, both in military [7] and civilian populations [5]. Similar associations were observed among police officers in the United Kingdom [6], Australian veterans of 1991 Golf war [8], Iraq–Iran war veterans [9], and in a large 22 years cohort of younger and middle age women in the United States [10]. What is very specific to our observation is the importance of the relation between these psychological factors and hypertension in an unselected general population of patients consulting an internal medicine department, and not in populations that were selected to present with high rates of PTSD, as in previous studies. Another specificity of our study is the hierarchical logistic regression analysis revealing that the relation between hypertension and PTSD, or trauma exposure was stronger than that with classical risk factors of hypertension, supporting a major role of traumatic events in the development of hypertension in this specific context.

Beyond the association with PTSD, which was the strongest in the logistic regression analysis, our data also show a specific association between man-made traumatic events and hypertension. Indeed, 61% of the population of hypertensive patients had been exposed to man-made trauma, against only 13% in normotensive patients. Notably, the prevalence of exposure to man-made trauma was above that of developing any psychiatric condition (PTSD, depression or alcohol-use-disorder), which was observed in 45% of the population (Table 2). This suggests that man-made trauma might participate to the development of hypertension independently of the development of PTSD, depression or alcohol use disorder. The importance of man-made trauma is further suggested by the fact that it remains an important independent factor related to hypertension in the multiple logistic regression analysis, which incorporates all psychiatric disorders, including PTSD. Few studies measured the direct association between traumatic event and hypertension, independently of PTSD diagnosis. Notably, among US military service members, the severity of initial injury was an independent risk factor of hypertension [7]. Our study found the association to be particularly significant for man-made traumatic events, suggesting that the latter have more deleterious effects than natural traumatic events. Accordingly, data extracted from 18 world health surveys (10 high-income countries, 8 low-income or middle-income countries) indicated that man-made disasters were more associated to PTSD than natural disasters [48], which is also in line with earlier reviews [49]. Our study is the first discriminating the different types of traumatic events suspected to have an impact on blood pressure.

Compared with normotensive individuals, patients with hypertension were also less likely to use adaptive emotion regulation strategies (i.e. cognitive reappraisal) and more likely to use maladaptive ones (i.e. expressive suppression). This result echoes a considerable number of studies suggesting an increased use of maladaptive regulation strategies in patients with hypertension [50,51]. Conversely, cognitive reappraisal has been identified as a protective factor against hypertension, and as such was associated with both higher drug adherence and a lower degree of drug resistance in patients with refractory and difficult-to-treat hypertension [27]. Our data confirm the suspected role of regulation of emotion as mediator between exposure to trauma and a pathological outcome such as hypertension.

Finally, and as expected in view of the large literature on the topic [52,53], patients with hypertension were also more likely to have depression and to suffer from alcohol use disorder. Of note, however, in a model including family history of hypertension, exposure to trauma, PTSD, depression and alcohol use disorder, this last factor was no more significant, suggesting that alcohol-related disorder was more an epiphenomenon related to PTSD. This hypothesis is even more likely as PTSD and alcohol use disorder are reported to be highly comorbid [24,54].

The study has some limitations. The sample size is modest, with the risk to overlook associations that may have reached significance in a larger cohort. Furthermore, we cannot exclude that differences between cases and controls, such as the higher proportion of women in the control group, though not significant, may have influenced the results. However, the study concerns a yet underexplored population of patients. Twenty-four hour ambulatory blood pressure monitoring was not performed, which may have led to misclassification of some participants as hypertensive or normotensives [55], but such practice is not common in the clinical context of Bukavu. Being a case–control study, our study cannot establish causal relations between the explored variables. Finally, self-reported measures, including PTSD and trauma-related ones, are subject to recall biases.

The conclusions from our study is in keeping with previous data from the literature, where hypertension is not only related to classical environmental and lifestyle factors but also to psychological factors, including trauma exposure and PTSD. However, in most previous studies performed in unselected hypertensive patients from high-income countries, psychological factors account only for a small part of the observed variance. In our study conducted in a tertiary hospital of Bukavu, Congo, the prevalence of trauma exposure was particularly high as a consequence of several decades of war. Due to this high prevalence, and possibly also to the metabolic conditions of that population,

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which is overall better than that of high-income countries, these psychological factors, far from being marginal, are strongly related to hypertension, and in particular more strongly than classical hypertension factors. Our observations suggest that psychological factors, and centrally man-made trauma, should be given a specific attention when managing hypertensive patients living in or coming from postconflict affected areas. Overall, PTSD and other psychological factors may be key contributing factors to hypertension in countries exposed to violence and in other countries in specific populations exposed to severe traumas, such as refugees, migrants and militaries. As a major clinical implication, in such context, trauma-focused treatment may have a preventive effect on hypertension.

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Conflicts of interest

There are no conflicts of interest.

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