REVIEW ARTICLE

Correlation Between Blood-pressure Levels and Frailty Index and Adverse Health Events in Older Adults With ESRD With Hypertension

Zhang Yapu, MM; Zhang Jiwei, MB; Ran Lei, MM; Chen Yinyin, MM

ABSTRACT

Context • End-stage renal disease (ESRD) refers to the development of chronic kidney disease to stage 5. Elevated blood pressure is one of the main symptoms of older adults with ESRD. The severity and difficulty of curing ESRD with hypertension in older adults has attracted a great deal of attention from the medical community.

Objective • The study intended to analyze the correlation between blood-pressure level and FRAIL scores and adverse health events for older adults with ESRD and hypertension.

Design • The research team performed a narrative review by searching hospital medical record system databases. The search used the keywords endpoint renal disease and hypertension. The research team also conducted a prospective case-control study.

Setting • The study took place at Affiliated Hospital of Hebei University.

Participants • Participants were 168 older adults with ESRD and hypertension, ESRD only, or hypertension only who had received a diagnosis and treatment at the hospital between October 2022 and September 2023 as well as healthy individuals who were members of the community.

Groups • The study included four groups, each with 42 participants: (1) the ESRD + hypertension group, (2) the ESRD group, (3) the hypertension group, and (4) the healthy group.

Outcome Measures • The research team: (1) measured systolic and diastolic blood pressure, (2) assessed patients' debilitation using the FRAIL score; and (3) determined the incidence of adverse health events—heart disease, stroke, cancer, arthritis, and chronic obstructive pulmonary disease (COPD). Based on participants' blood pressures, the research team: (1) divided the ESRD with hypertension group into the hypertension grade I, hypertension grade II, and hypertension grade III groups, and (2) compared the blood pressures, FRAIL scores, and incidence of adverse health events among those three groups. The team performed a Pearson correlation analysis to analyze the correlation between blood pressure and the FRAIL scores and adverse health events for the ESRD with hypertension group.

Results • The ESRD + hypertension group's mean systolic and diastolic blood pressure and FRAIL score and its incidence of adverse health events were significantly higher than those: (1) of the ESRD group, with $P = .028$, $P = .048$, $P = .037$, and $P = .008$, respectively; (2) of the hypertension group, with $P = .017$, $P = .035$, $P = .025$, and $P = .037$, respectively; and (3) of the healthy group, with $P = .042$, $P = .341$, $P = .372$, and $P = .482$, respectively. The hypertension grade III's systolic and diastolic blood pressure, FRAIL score, and incidence of adverse health events were significantly higher than those: (1) of the hypertension grade I group, with $P = .009$, $P = .015$, $P = .003$, and $P = .055$, respectively, and (2) of the grade II group, with $P = .078$, $P = .089$, $P = .001$, and $P = .006$, respectively. A significant positive correlation existed between the blood-pressure level and the FRAIL score ($P = .041$) and incidence of adverse health events ($P = .032$).

Conclusions • Older adults with ESRD and hypertension had significantly higher blood pressure levels and FRAIL scores and more adverse health events. A significant positive correlation existed between blood pressure level and frailty scores and incidence of adverse health events. (*Altern Ther Health Med.* [E-pub ahead of print.])

Zhang Yapu, MM, Department of Nephrology, Affiliated Hospital of Hebei University, Baoding, China; **Zhang Jiwei,** MB, Department of Cardiovascular Medicine, Affiliated Hospital of Hebei University; Baoding, China; **Ran Lei,** MM, Department of Nephrology, Affiliated Hospital of Hebei University, Baoding, China; **Chen Yinyin,** MM, Department of Geriatric Medicine, Affiliated Hospital of Hebei University, Baoding, China;

Corresponding author: Ran Lei, MM
E-mail: Lwfb1x@sina.com
Corresponding author: Chen Yinyin, MM
E-mail: 1042137109@qq.com

End-stage renal disease (ESRD) refers to the development of chronic kidney disease to stage 5; patients' glomerular filtration rate is lower than 15 ml per minute and patients have uremia and require renal replacement therapy.[1] ESRD is a syndrome formed when chronic renal failure develops to the end-stage. ESRD's initial symptoms aren't obvious, and with the continuous decline in renal function, toxins accumulate in the body, which produces a series of symptoms of uremia, such as nausea and vomiting, loss of appetite, edema, itchy skin, and fatigue.

The disease can cause material metabolic disorders and systemic-function damage that can seriously affect patients' physical and mental health and their quality of life and even threaten their lives. Many complications and high mortality characterize the disease, and clinicians should actively treat it. ESRD has received national attention in China, and its prevention and treatment are currently important public-health issues.

Hypertension

Hypertension is a common chronic disease in clinical practice, mainly characterized by elevated blood-pressure levels, and its occurrence and development are closely related to unhealthy lifestyles.[2] ESRD and hypertension are both chronic noncommunicable diseases, with the majority of patients being older adults, and the diseases' prevalence has been increasing in recent years due to the aging of populations.[3]

Elevated blood pressure is one of the main symptoms of older adults with ESRD, and clinicians base a diagnosis of hypertension on blood-pressure levels. Hypertension occurs mainly due to arterial contraction and diastole of the blood-vessel wall, resulting in a rise in blood pressure to a level greater than normal; the main factors include a poor diet, unhealthy lifestyle, overweight or obesity, smoking, drinking, and mental stress.[4]

Also, with age, atherosclerosis gradually increases and arterial-dilatation capacity decreases, so simple systolic hypertension often occurs while systolic blood pressure remains unchanged or decreases, resulting in an increase in pulse pressure. Men are more likely to smoke and drink alcohol, so the prevalence is higher than that of women.[5]

The incidence of hypertension is high, and the current number of hypertensive patients around the world has reached one-billion as of 2022, with the number of hypertensive patients in China having reached about 200-million.[6]

In mild cases, hypertension doesn't cause any symptoms, while in moderate-to-severe cases, it often causes dizziness, headaches, panic attacks, and in some cases, multi-organ damage. Asus et al reported that the disease is a risk factor for cardiovascular and cerebrovascular diseases and increases the risk of stroke and heart disease.[7] Therefore, it's very important to actively prevent and control hypertension.

ESRD and Hypertension

The relationship between ESRD and hypertension is close; the two are causative of each other; and each affects the progress of the other. ESRD increases the risk of hypertension, with the prevalence rate of hypertension in ESRD patients being up to 80%.[8] Hypertension is a high-risk factor for cardiovascular and cerebrovascular diseases in patients with ESRD and is the main cause of death.[9]

The mechanism that induces hypertension in older-adult patients with ESRD is complex, mainly related to the great volume load of Blood-vessel walls and the increase in vasoconstrictor active substances.[10] The causes of that increase include increased activity of the renin-angiotensin-aldosterone system, increased sympathetic activity, clearance of antihypertensive drugs by dialysis therapy, sodium and volume overload, erythropoietin, endothelium-derived factor abnormalities, prostaglandin/bradykinin abnormalities, a decreased number of renal units, impairment of vascular endothelial function, and decreased arterial compliance.[11]

The severity and difficulty of curing ESRD with hypertension in older adults has attracted a great deal of attention from the medical community.

Debilitation

Older adults can be susceptible to debilitation because of reduced body function, cognitive decline, and elevated susceptibility to adverse outcomes.[12] The fatigue-resistance-ambulation-illness-loss of weight (FRAIL) index is a commonly used index for assessing frailty and provides a multidimensional evaluation of physical-fitness levels in older adults with a high degree of accuracy.[13,14]

The FRAIL index, a multidimensional concept that captures the overall health status of an individual, has gained recognition as a valuable tool for predicting adverse health events in the older-adult population. It encompasses various physical, psychological, and social factors that contribute to vulnerability and decline in functional capacity. In the context of ESRD, the FRAIL index holds promise for providing insights into the complex interplay between blood-pressure levels, frailty, and adverse health events in older-adult patients.

ESRD with hypertension can result in poor physical function and a high incidence of adverse health events, such as heart disease, stroke, and cancer.[15] Clinicians should highly emphasize and aggressively treat the disease to improve patients' prognoses and enhance their quality of survival.

Adverse Health Events

Older-adult patients with ESRD are prone to adverse health events because of their significantly diminished renal function and poor level of physical health. Hypertension is also a high risk factor for cardiovascular diseases, which further increases the risk of adverse health events in older-adult patients with ESRD and hypertension.

Fang et al reported a significant correlation between the FRAIL index and age, type of antihypertensive medication, stroke, cancer, arthritis, chronic kidney disease, number of co-morbidities, and blood pressure in older-adult patients.[16] Those researchers found that the incidence of frailty increases with age. The FRAIL index also assesses the prognosis of older-adult hospitalized patients and is predictive of risk of death.

Current Study

Understanding the correlation between blood-pressure levels, FRAIL scores, and adverse health events in older-adult patients with ESRD and hypertension is crucial to optimizing their care and improving their quality of life.

The current study intended to analyze the correlation between blood-pressure level and FRAIL scores and adverse health events for older adults with ESRD and hypertension.

METHODS: LITERATURE REVIEW

Procedures

The study took place at Affiliated Hospital of Hebei University. The research team performed a narrative review by searching hospital medical record system databases. The search used the keywords ERSD and hypertension.

The review encompassed studies that investigated the relationship between blood-pressure levels, the FRAIL index, and adverse health events in older-adult patients with ESRD

and hypertension. It included articles published in the Pubmed language. To assure the validity of the data, the research team strictly followed the double-blind randomized control rule.

The team analyzed the data from relevant clinical trials, observational studies, and cohort studies to identify patterns, trends, and potential correlations between variables.

Methods: CASe-Control Study

Participants

The research team also conducted a prospective case-control study. Potential participants were older adults with ESRD and hypertension, ESRD only, or hypertension only who had received a diagnosis and treatment at the hospital between October 2022 and September 2023 as well as healthy individuals who were members of the community

The study included potential participants in the ESRD with hypertension group if they: (1) were aged ≥60 years; (2) had received a clinical diagnosis of ESRD with hypertension and also met the diagnostic provisions of the *Diagnosis, Identification and Typing and Efficacy Assessment of Chronic Renal Failure (Trial Program)* regarding end-stage renal disease[17] as well as the diagnostic provisions of the *Guidelines for the Prevention and Treatment of Hypertension in* China, 2023 edition regarding hypertension[18]; (3) had complete medical records available; and (4) understood the study's content and had volunteered to participate.

The study excluded potential participants from the ESRD with hypertension group if they had: (1) other organ diseases, (2) diabetes mellitus, (3) infectious diseases,(4) hematologic diseases, (5) cancer, or (6) psychiatric diseases.

The study included potential participants in the ESRD group if they: (1) were aged ≥60 years; (2) had received a clinical diagnosis of ESRD and also met the diagnostic provisions of the *Diagnosis, Diagnostic Typing, and Efficacy Assessment of Chronic Renal Failure (Trial Program)* regarding end-stage renal disease[17]; (3) had complete medical records available; and (4) understood the study's content and volunteered to participate.

The study excluded potential participants from the ESRD group if they had: (1) other organ diseases, (2) hypertension, (3) diabetes mellitus, (4) infectious diseases, (5) hematological diseases, (6) cancer, or (7) psychiatric diseases.

The study included potential participants in the hypertension group if they: (1) were aged ≥60 years. (2) had received a clinical diagnosis of hypertension and also met the diagnostic provisions of the *Chinese Guidelines for the Prevention and Treatment of Hypertension, 2023 edition*[7]; (3) had complete medical records available; and (4) understood the study's content and volunteered to participate.

The study excluded potential participants from the hypertension group if they had: (1) renal or other organ diseases, (2) diabetes mellitus, (3) infectious diseases, (4) hematological diseases, (5) cancer, or (6) psychiatric diseases.

The study included potential participants in the healthy group if they: (1) were aged ≥60 years, (2) were in good physical health, (3) had data available from a complete physical examination, and (4) understood the study's content and volunteered to participate.

The study excluded potential participants from the healthy group if they had: (1) renal or other organ diseases, (2) hypertension, (3) diabetes mellitus, (4) infectious diseases, (5) hematological diseases, (6) cancer, or (7) psychiatric diseases.

Procedures

Groups. The study included four groups, each with 42 participants: (1) the ESRD + hypertension group, (2) the ESRD group, (3) the hypertension group, and (4) the healthy group.

Data collection. The researchers collected the main data through the hospital medical record system and obtained sufficient follow-up data through telephone follow-up.

Blood-pressure level. The research team measured the systolic and diastolic blood pressures in the right upper limb's brachial artery using an Omron HEM-7052 arm-type, fully automatic, electronic sphygmomanometer (Beijing, China). Half an hour before the measurement of blood pressure, the team instructed the patients not to drink coffee or alcohol or perform strenuous exercise and to rest calmly for 10 minutes.

Hypertension grade. According to participants' blood-pressure levels, the research team grouped patients in the ESRD + hypertension group into three grades: (1) the hypertension grade I group, with 13 participants—systolic blood pressure 140 mmHg-159 mmHg and/or diastolic blood pressure 90 mmHg-99 mmHg, (2) the hypertension grade II group, with 19 participants—systolic blood pressure 160 mmHg-179 mmHg and/or diastolic blood pressure 100 mmHg-109 mmHg, and (3) the hypertension grade III group, with 10 participants—systolic blood pressure ≥180mmHg and/or diastolic blood pressure ≥110mmHg.

Outcome measures

The research team: (1) measured systolic and diastolic blood pressure, (2) assessed patients' debilitation using the FRAIL score; and (3) determined the incidence of adverse health events—heart disease, stroke, cancer, arthritis, and chronic obstructive pulmonary disease (COPD). Based on their blood pressures, the research team: (1) divided the ESRD with hypertension group into the hypertension grade I, hypertension grade II, and hypertension grade III groups, and (2) compared the blood pressures, FRAIL scores, and incidence of adverse health events among those three groups. The team performed a Pearson correlation analysis to analyze the correlation between blood pressure and the FRAIL scores and adverse health events for the ESRD with hypertension group.

Outcome Measures

Blood pressure and FRAIL scores.[19,20] The team used the average of two consecutive measurements of the systolic and diastolic blood pressures, with a 10-minute interval. If the difference between the two measurements was >10 mmHg, the team took a third measurement and used the average of the three measurements.

The FRAIL scale has five dimensions: (1) conscious fatigue, (2) decreased endurance/increased resistance, (3) decreased free movement, (4) the presence of >5 chronic diseases, and (5) weight loss of ≥5% within one year. The total score is 0-5, with 0 = no debilitation, 1-2 = pre-debilitation, and 3-5 = debilitation. the lower the score, the better the patient's condition.[21] We have accumulated the scores for each sub item and added them up to get the total score.

Adverse health events. The events included heart disease, stroke, cancer, arthritis, and chronic obstructive pulmonary disease (COPD). The research team calculated the total incidence rate.

Subgroups' blood pressure and FRAIL scores. Using the same methods described above, the research team assessed blood pressures and FRAIL scores for the hypertension grades I, II, and III groups.

Subgroups' adverse health events. Using the same methods described above, the research team assessed adverse health events for the hypertension grades I, II, and III groups.

Correlation analysis. For the Pearson's correlation analysis for the ESRD with hypertension group, blood pressure was the dependent variable and FRAIL score and adverse health events were the independent variables.

Table 1. Participants' Demographic and Clinical Characteristics at Baseline (N=168)

Characteristics	ESRD + Hypertension Group n=42 n (%) Mean ± SD	ESRD Group n=42 n (%) Mean ± SD	Hypertension Group n=42 n (%) Mean ± SD	Healthy Group n=42 n (%) Mean ± SD
Gender				
Male	23 (54.76)	24 (57.14)	22 (52.38)	21 (50.00)
Female	19 (45.24)	18 (42.86)	20 (47.62)	21 (50.00)
Age, y				
Mean	72.48 ± 3.22	72.50 ± 3.19	72.52 ± 3.17	72.53 ± 3.15
Range	60-84	60-84	60-83	60-84
BMI, kg/m²				
Mean	22.41 ± 1.07	22.38 ± 1.09	22.39 ± 1.07	22.40 ± 1.05
Range	19-27	19-27	19-27	19-27
Duration of Nephropathy, y				
Mean	10.83 ± 2.70	10.86 ± 2.67	-	-
Range	1-16	1-16	-	-
Duration of Hypertension, y				
Mean	7.90 ± 2.24	-	7.93 ± 2.22	-
Range	1-14	-	1-14	-
Primary Nephropathy				
Chronic glomerulonephritis	14 (33.33)	13 (30.95)	-	-
Diabetic nephropathy	11 (26.19)	12 (28.57)	-	-
Hypertensive nephropathy	8 (19.05)	8 (19.05)	-	-
Obstructive nephropathy	6 (14.29)	6 (14.29)	-	-
Other origins	3 (7.14)	3 (7.14)	-	-

Comparison	ESRD + Hypertension and ESRD Groups		ESRD + Hypertension and Hypertension Groups		ESRD + Hypertension and Healthy Groups		ESRD and Hypertension Groups	
	χ^2/*t* value	*P* value	χ^2/*t* value	F value	χ^2/*t* value	*P* value	χ^2/*t* value	*P* value
Gender	0.87	.934	0.46	0.48	0.73	.345	0.93	.782
Age, y	0.65	.782	0.35	0.67	0.65	.472	1.23	.067
BMI, kg/m²	0.94	.163	0.26	0.57	0.48	.382	0.48	.083
Duration of Nephropathy, y	0.83	.263	-	-	-	-	-	-
Duration of Hypertension, y	-	-	0.17	0.76	-	-	-	-
Primary Nephropathy	97.34	.372	-	-	-	-	-	-

Comparison	ESRD + Healthy Groups		Hypertension and Healthy Groups	
	χ^2/*t* value	*P* value	χ^2/*t* value	*P* value
Gender	0.47	1.291	0.23	.893
Age, y	0.38	.891	0.36	.782
BMI, kg/m²	0.65	.749	0.46	.653
Duration of Nephropathy, y	-	-	-	-
Duration of Hypertension, y	-	-	-	-
Primary Nephropathy	-	-	-	-

Statistical Analysis

The research team analyzed the data using the SPSS 20.0 program (California, USA). The team: (1) expressed continuous data as means ± standard deviations (SDs) and compared the groups using the *t* test, and (2) expressed categorical data as numbers (Ns) and percentages (%) and compared the data using the Chi-square (χ^2) test. $P < .05$ indicated statistically significant differences.

RESULTS: CASE-CONTROL STUDY

Participants

The research team included and analyzed the data of 168 participants, 42 in each of the four groups (Table 1). The ESRD + hypertension group included 23 males (54.76%) and 19 females (45.24%), ranging in age from 60 to 84 y with a mean age of 72.48 ± 3.22 y. The group's: (1) body mass index (BMI) ranged from 19 to 27 kg/m² with a mean BMI of 22.41 ± 1.07 kg/m²; (2) duration of ESRD ranged from one to 16 y with a mean duration of 10.83 ± 2.70 y; (3) duration of hypertension ranged from one to 14 y with a duration of 7.90 ± 2.24 y; (4) primary nephropathies included 14 participants with chronic glomerulonephritis (33.33%), 11 with diabetic nephropathy (26.19%), 8 with hypertensive nephropathy (19.05%), six with obstructive nephropathy (14.29%), and three with other origins (7.14%).

The ESRD group included 24 males (57.14%) and 18 females (42.86%), ranging in age from 60 to 84 y with a mean age of 72.50 ± 3.19 y. The group's: (1) BMI ranged from 19 to 27 kg/m² with a mean BMI of 22.38 ± 1.09 kg/m²; (2) duration of nephropathy ranged from one to 16 y with a mean duration of 10.86 ± 2.67 y; and (3) primary nephropathies included 13 participants with chronic glomerulonephritis (30.95%), 12 with diabetic nephropathy (28.57%), eight with hypertensive nephropathy (19.05%), six with obstructive nephropathy (14.29%), and three with other origins (7.14%).

The hypertension group included 22 males (52.38%) and 20 females (47.62%), ranging in age from 60 to 83 y with a mean age of 72.52 ± 3.17 y. The group's: (1) BMI ranged from 19 to 27 kg/m² with a mean BMI of 22.39 ± 1.07 kg/m² and (2) duration of hypertension ranged from one to 14 y with a mean duration of 7.93 ± 2.22 y.

The healthy group included 21 men (50.00%) and 21 women (50.00%), ranging in age from 60 to 84 y with a mean age of 72.53 ± 3.15 y. The group's BMI ranged from 19 to 27 kg/m² with a mean BMI of 22.40 ± 1.05 kg/m².

No significant differences existed: (1) among the four groups in gender, age, or BMI (all $P > .05$); (2) between the

ESRD + hypertension and ESRD groups in the duration of nephropathy or primary nephropathy (both $P > .05$); (3) between the ESRD + hypertension and hypertension groups in the duration of hypertension ($P > .05$).

Blood Pressure and FRAIL Scores

The ESRD + hypertension group's mean systolic blood pressure, diastolic blood pressure, and FRAIL score were 162.25 ± 13.30 mmHg, 103.57 ± 6.11 mmHg, and 3.82 ± 0.74 points, respectively (Table 2).

The ESRD group's mean systolic blood pressure, diastolic blood pressure, and FRAIL score were 134.17 ± 10.12 mmHg, 82.36 ± 5.29 mmHg, and 3.24 ± 0.66 points, respectively.

The hypertension group's mean systolic blood pressure, diastolic blood pressure, and FRAIL score were 156.51 ± 12.88 mmHg, 98.25 ± 6.25 mmHg, and 3.16 ± 0.61 points, respectively.

The healthy group's mean systolic blood pressure, diastolic blood pressure, and FRAIL score were 127.34 ± 10.01 mmHg, 80.18 ± 5.44 mmHg, and 2.07 ± 0.45 points, respectively.

The ESRD + hypertension group's mean systolic blood pressure ($P = .028$), diastolic blood pressure ($P = .048$), and FRAIL score ($P = .037$) were significantly higher than those of the ESRD group.

The ESRD + hypertension group's mean systolic blood pressure ($P = .025$), diastolic blood pressure ($P = .037$), and FRAIL score ($P = .042$) were significantly higher than those of the hypertension group.

The ESRD + hypertension group's mean systolic blood pressure ($P = .008$), diastolic blood pressure ($P = .017$), and FRAIL score ($P = .035$) were significantly higher than those of the healthy group.

Table 2. Comparison of Blood Pressure Levels and FRAIL Scores for the Nephropathy With Hypertension, Nephropathy, Hypertension, and Healthy Groups

Variable	ESRD + Hypertension Group n=42 Mean ± SD		ESRD Group n=42 Mean ± SD		Hypertension Group n=42 Mean ± SD		Healthy Group n=42 Mean ± SD	
Systolic blood pressure, mmHg	162.25 ± 13.30		134.17 ± 10.12		156.51 ± 12.88		127.34 ± 10.01	
Diastolic blood pressure, mmHg	103.57 ± 6.11		82.36 ± 5.29		98.25 ± 6.25		80.18 ± 5.44	
FRAIL score	3.82 ± 0.74		3.24 ± 0.66		3.16 ± 0.61		2.07 ± 0.45	
	ESRD + Hypertension and ESRD Groups		ESRD + Hypertension and Hypertension Groups		ESRD + Hypertension and Healthy Groups		ESRD and Hypertension Groups	
Comparison	F value	*P* value	F value	*P* value	F value	*P* value	F value	*P* value
Systolic blood pressure, mmHg	9.83	.028[a]	93.24	.008[a]	36.45	.025[a]	0.40	.341
Diastolic blood pressure, mmHg	36.34	.048[a]	37.46	.017[a]	87.37	.037[a]	0.29	.372
FRAIL score	23.48	.037[a]	28.94	.035[a]	46.73	.042[a]	0.23	.482
	ESRD and Healthy Groups		Hypertension and Healthy Groups					
Comparison	F value	*P* value	F value	*P* value				
Systolic blood pressure, mmHg	0.37	0.172	0.92	.253				
Diastolic blood pressure, mmHg	0.38	0.189	0.34	.285				
FRAIL score	0.38	0.196	0.23	.1892				

[a]$P < .05$, indicating that the nephropathy with hypertension group's mean systolic blood pressure, diastolic blood pressure, and FRAIL score were significantly higher than those of the nephropathy, hypertension, and healthy groups

Abbreviation: FRAIL, fatigue/resistance/ambulation/illness/loss of weight

Table 3. Comparison of the Incidence of Adverse Health Events for the Nephropathy With Hypertension, Nephropathy, Hypertension, and Healthy Groups

Adverse Event	ESRD + Hypertension Group n=42 n (%)		ESRD Group n=42 n (%)		Hypertension Group n=42 n (%)		Healthy Group n (%) n=42	
Heart disease	2 (4.76)		2 (4.76)		1 (2.38)		0 (0.00)	
Cerebral apoplexy	3 (7.14)		1 (2.38)		3 (7.14)		1 (2.38)	
Cancer	1 (2.38)		0 (0.00)		0 (0.00)		0 (0.00)	
Arthritis	4 (9.52)		2 (4.76)		2 (4.76)		2 (4.76)	
Chronic obstructive pulmonary disease	5 (11.91)		2 (4.76)		3 (7.14)		2 (4.76)	
Total incidence	15 (35.71)		7 (16.67)		9 (21.43)		5 (11.91)	
	ESRD + Hypertension and ESRD Groups		ESRD + Hypertension and Hypertension Groups		ESRD + Hypertension and Healthy Groups		ESRD and Hypertension Groups	
Comparison	χ^2 value	*P* value	χ^2 value	*P* value	χ^2 value	*P* value	χ^2 value	*P* value
Total incidence rate	39.44	<.009[a]	89.38	<.015[a]	67.83	<.003[a]	1.48	<.055
	ESRD and Healthy Groups		Hypertension and Healthy Groups					
Comparison	χ^2 value	*P* value	χ^2 value	*P* value				
Total incidence rate	1.38	.078	1.39	<.089				

[a]$P < .05$, indicating that the nephropathy + hypertension group's total incidence rate was significantly higher than those of the nephropathy, hypertension, and healthy groups

Adverse Health Events

The ESRD + hypertension group's adverse events included two participants with heart disease (4.76%), three with cerebral apoplexy (7.14%), one with cancer (2.38%), four with arthritis (9.52%), and five with COPD (11.91%), for a total incidence of 35.71% for 15 participants (Table 3).

The ESRD group's adverse events included two participants with heart disease (4.76%), one with cerebral apoplexy (2.38%), none with cancer (0.00%), two with arthritis (4.76%), and two with COPD (4.76%), for a total incidence of 16.67% for seven participants.

The hypertension group's adverse events included one participant with heart disease (2.38%), three with cerebral apoplexy (7.14%), none with cancer (0.00%), two with arthritis (4.76%), and three with COPD (7.14%), for a total incidence of 21.43% for nine participants.

The healthy group's adverse events included no participants with heart disease (0.00%), one with cerebral apoplexy (2.38%), none with cancer (0.00%), two with arthritis (4.76%), and two with COPD (4.76%), for a total incidence of 11.91% for five participants.

The ESRD + hypertension group's total incidence rate was significantly higher than those of the ESRD ($P = .009$), hypertension ($P = .015$), and healthy groups ($P = .003$).

Subgroups' Blood Pressure and FRAIL Scores

The hypertension grade I group's mean systolic blood pressure, diastolic blood pressure, and FRAIL score were 145.93 ± 11.90 mmHg, , 95.85 ± 6.03 mmHg, and 3.24 ± 0.69 points, respectively (Table 4).

The hypertension grade II group's mean systolic blood pressure, diastolic blood pressure, and FRAIL score were 163.04 ± 12.85 mmHg, 104.82 ± 6.27 mmHg, and 3.71 ± 0.69 points, respectively.

Table 4. Comparison of Blood Pressure Levels and FRAIL Index for the Hypertension Class I, II, and III Groups

Variable	Hypertension Grade I Group n=13 Mean ± SD		Hypertension Grade II Group n=19 Mean ± SD		Hypertension Grade III Group n=10 Mean ± SD	
Systolic blood pressure, mmHg	145.93 ± 11.90		163.04 ± 12.85		181.34 ± 13.23	
Diastolic blood pressure, mmHg	95.85 ± 6.03		104.82 ± 6.27		110.63 ± 6.88	
FRAIL score	3.24 ± 0.69		3.71 ± 0.69		4.14 ± 0.77	
	Hypertension Grade I and Grade II Groups		Hypertension Grade I and Grade III Groups		Hypertension Grade II and Grade III Groups	
Comparison	F value	*P* value	F value	*P* value	F value	*P* value
Systolic blood pressure, mmHg	233.34	.0001[a]	211.36	.0003[a]	254.93	.123
Diastolic blood pressure, mmHg	178.89	.0003[a]	203.74	.0005[a]	187.34	.243
FRAIL score	198.99	.0006[a]	206.87	.0006[a]	167.34	.352

[a]*P* < .001, indicating that the hypertension grade III group's mean systolic blood pressure, diastolic blood pressure, and FRAIL score were significantly higher than those of the hypertension grade I and II groups

Abbreviations FRAIL, fatigue/resistance/ambulation/illness/loss of weight

Table 5. Comparison of the Incidence of Adverse Health Events for the Hypertension Class I, II, and III Groups

Adverse Event	Hypertension Grade I Group n=13 n (%)		Hypertension Grade II Group n=19 n (%)		Hypertension Grade III Group n=10 n (%)	
Heart disease	0 (0.00)		1 (5.26)		1 (10.00)	
Cerebral apoplexy	0 (0.00)		1 (5.26)		2 (20.00)	
Cancer	0 (0.00)		0 (0.00)		1 (10.00)	
Arthritis	1 (7.69)		2 (10.53)		1 (10.00)	
Chronic obstructive pulmonary disease	1 (7.69)		3 (15.79)		1 (10.00)	
Total incidence rate	2 (15.38)		7 (36.84)		6 (60.00)	
	Hypertension Grade I and Grade II Groups		Hypertension Grade I and Grade III Groups		Hypertension Grade II and Grade III Groups	
Adverse Event	χ^2 value	*P* value	χ^2 value	*P* value	χ^2 value	*P* value
Total incidence rate	25.57	0.041	17.93	.032	0.29	.123

[a]*P* < .05, indicating that the hypertension grade III group's total incidence rate was significantly higher than those of the hypertension grade I and II groups

Table 6. Correlation Analysis of Blood Pressure Level With Frailty Index and Adverse Health Events for the Nephropathy With Hypertension Group

Variable	R Value	*P* value
FRAIL score	0.545	.037[a]
Adverse health event	0.474	.017[a]

[a]*P* < .05, indicating that blood pressure level was significantly correlated with the nephropathy with hypertension group's FRAIL score and incidence of adverse events

Abbreviations: FRAIL, fatigue/resistance/ambulation/illness/loss of weight

The hypertension grade III group's mean systolic blood pressure, diastolic blood pressure, and FRAIL score were 181.34 ± 13.23 mmHg, 110.63 ± 6.88 mmHg, and 4.14 ± 0.77 points, respectively.

The hypertension grade III group's mean systolic blood pressure (*P* = .0001, diastolic blood pressure (*P* = .0003), and FRAIL score (*P* = .0006) were significantly higher than those of the hypertension grade I group.

The hypertension grade III group's mean systolic blood pressure (*P* = .0003), diastolic blood pressure (*P* = .0005), and FRAIL score (*P* = .0006) were significantly higher than those of the hypertension grade II group.

Subgroups' Adverse Health Events

The hypertension grade I group's adverse events included no participants with heart disease (0.00%), none with cerebral apoplexy (0.00%), none with cancer (0.00%), one with arthritis (7.69%), and one with COPD (7.69%), for a total incidence of 15.38% for two participants (Table 5).

The hypertension grade II group's adverse events included one participant with heart disease (5.26%), one with cerebral apoplexy (5.26%), none with cancer (0.00%), two with arthritis (10.53%), and one with COPD (15.79%), for a total incidence of 36.84% for seven participants.

The hypertension grade III group's adverse events included one participant with heart disease (10.00%), two with cerebral apoplexy (20.00%), one with cancer (10.00%), one with arthritis (10.00 %), and one with COPD (10.00%), for a total incidence of 60.00% for 10 participants.

The hypertension grade III group's total incidence rate was significantly higher than those of the hypertension grade I (*P* = .041) and II groups (*P* = .032).

Correlation Analysis

Table 6 shows that the Pearson's correlation analysis found a significant positive correlation existed between participants' blood pressure and their FRAIL scores (r=0.474, *P* = .037) and adverse health events (r=0.545, p=0.017).

DISCUSSION

The current study showed that the ESRD + hypertension group's blood-pressure levels were significantly higher than those of the other three groups, suggesting that ESRD with hypertension may cause elevated blood-pressure levels and that simultaneous occurrence of the two disorders can lead to a significant increase in blood-pressure levels. The study also found a gradual increase in blood-pressure levels from that of the hypertension grade I group to that of the hypertension grade III group. The hypertension grade III group's levels were significantly higher than those of the other two groups, indicating that the higher the classification of hypertension, the higher the blood pressure level.

The current study showed that the ESRD + hypertension group's FRAIL scores were significantly higher than those of the other three groups, which suggests that ESRD with hypertension can exacerbate the symptoms of debility in older adults and that the symptoms of debility in older-adult patients with ESRD and hypertension are particularly prominent.

The current study also showed that the ESRD + hypertension group's rate of adverse health events was significantly higher than that of the other three groups, which suggests that ESRD with hypertension can lead to an elevated risk of adverse health events, greatly reducing patients' health.

The current study also showed that the hypertensive group III's incidence of adverse events was significantly higher than that of the other two groups and that a gradual increase in events occurred from that of the hypertension grade I group to that of the hypertension grade III group, suggesting that the higher the blood-pressure level of the

older-adult patients with ESRD with hypertension, the higher the incidence of adverse health events.

The current study also analyzed the correlation between blood pressure level, FRAIL score, and adverse health events in the ESRD + hypertension group, and a significant positive correlation existed between the blood-pressure level and the FRAIL score and adverse health events, which suggests that actively controlling blood pressure in older-adult patients with ESRD with hypertension can help to reduce patients' debilitating symptoms and reduce the risk of adverse health events.

By examining the above relationships, the current study aimed to provide valuable insights that can guide healthcare professionals in tailoring interventions and strategies to better manage this complex population. Ultimately, the findings from this research may contribute to the development of evidence-based guidelines and policies that address the specific needs of older-adult patients with ESRD and hypertension.

The current findings from the research will not only contribute to the existing body of knowledge but also inform healthcare professionals, policymakers, and researchers in developing targeted interventions to improve the overall health outcomes of older-adult patients with ESRD and hypertension.

CONCLUSIONS

Older adults with ESRD and hypertension had significantly higher blood pressure levels and FRAIL scores and more adverse health events. A significant positive correlation existed between blood pressure level and frailty scores and incidence of adverse health events.

AUTHOR CONTRIBUTIONS

These authors should be seen as co-first authors: Zhang Yapu and Zhang Jiwei.

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