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Homeostatic effect of DASH and Alkaline-Based Diet on blood electrolytes and lipid profiles among cardiac patients: a comparative study

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Abstract:

Subjects with congestive heart failure (CHF) usually show acid–base and electrolyte disturbances, due both to the activation of several neurohumoral mechanisms and to drugs used in this condition, such as diuretics. Acidosis induces release of catecholamines, which attenuate both the negative inotropic effect of acidosis on cardiac contractility and the peripheral vasodilatory effect of acidemia that determined by the fall of pH in the intracellular fluid. Alkaline and DASH diets have been advocated to achieve better health outcomes in cardiac patients and their conditions by shifting dietary choices to more "alkaline" alternatives, thereby preventing severe complications. The purpose of this study was to investigate the therapeutic efficacy of DASH and alkaline-based diets on the clinical profiles of cardiac patients.

Method: an intervention case-control study was conducted on one hundred hypertensive cardiac adult patients, they divided into control group who prescribed their medications only; other DASH and alkaline groups followed the therapeutic diets for 21 consecutive days. Then dietary consumption was computed to determine nutritional requirements. Serum electrolytes, blood pressure measures serum lipid profiles and urinary pH were been assessed.

Results: Throughout the post-intervention periods, blood sodium and bicarbonate reduced statistically significant ($P \leq 0.001$) with an alkaline diet rather than a DASH diet, whereas potassium and calcium were increased; blood bicarbonate was reduced considerably ($P \leq 0.001$) with an alkaline diet rather than a DASH diet. Urinary pH was altered considerably in both DASH and alkaline groups, while Systolic and diastolic blood pressure were improved considerably ($P \leq 0.001$) with no differences between them.

Conclusion: The study concluded that acidosis was reduced considerably after nutritional intervention with an alkaline diet vs. a DASH diet.

Keywords: Alkaline Diet, sodium, calcium, bicarbonate, acidosis.

Introduction

Heart failure (HF) is a systemic disorder with a high prevalence, mortality, and healthcare costs, making it a serious social and economic public health issue (**Ghali et al., 1990**). Myocardial systolic and diastolic abnormalities cause reduced cardiac output, which is the pathophysiology of HF. Compensatory mechanisms are triggered, including left ventricular dilation and sympathetic and renin-angiotensin-aldosterone systems (RAAS) activation, resulting in a vicious cycle of systemic vasoconstriction, increased blood pressure, heart rate, sodium and water retention despite existing volume overload (**Masson et al., 2010**). Lowering systolic blood pressure decreases the risk of heart failure by around 12%, according to the framingham heart study (**Levitan et al., 2009**).

The simultaneous Na^{+} load may be sufficient to reverse the function of the $3Na^{+}/2Ca^{2+}$ exchanger, raising $Ca2^{+}$ and increasing the risk of ventricular arrhythmia (**Bai et al., 2017**). Compensatory acid-extrusion, which imposes double the Na^{+} load per HCO3- equivalent, is one approach proposed to promote cardiomyocyte hypertrophy in spontaneously hypertensive rats as mentioned by **Orlowski et al., (2014)**.

Blood pH levels indicate the net buffering and excretion of all acids and bases in the human body. Predictable risk factors, such as diet and lifestyle changes (**Rifai and Silver, 2016**), are responsible for 75 percent of cardiovascular disease deaths, according to the World Health Organization (**WHO, 2021**).

Food has an influence on the pH of the body and urine. If the diet does not contain enough alkaline minerals to compensate, acids will build up in the cells (**Leech, 2016**). The body has crucial regulatory systems in place to maintain a pH of 7.35 in the blood (and other cells); the most common technique is to eliminate acids in the urine. The preservation of blood pH under a 40–70 mEq H^+/day dietary and metabolic acid load (net endogenous acid production: NEAP) implies substantial homeostatic mechanisms (**Amodu and Abramowitz, 2013**). Metabolic acidosis (MAc) which reduces heart rate due to the intricate effects of acidosis on the sympathoadrenal system, is linked to impaired cardiac contractility (**Orchard and Kentish, 1990**). Intracellular acidosis in myocardial infarction after a period of ischemia is resisted after reperfusion (**Ten-Hove et al., 2005**). MAc also prevents vascular calcification from advancing, which is an important trait (**Al-Aly, 2008**).

In congestive heart failure, diuretics are used to lower blood pressure, whereas acid-base medications target the vasculature directly. Although several alkali-containing drugs may hasten the progression of vascular calcification (**Fernandez-Fernandez et al., 2014**), the carbonic anhydrase (CA) blocker Acetazolamide (ACZ) shows therapeutic benefit in calcifying disease, perhaps through lowering pH (**Zhang et al., 2018**). There is potential for dietary control of metabolic acidosis, such as adopting a low-protein diet (**Di-Iorio et al., 2017**) or otherwise "alkaline" diet (**Goraya et al., 2019**), assuming that dietary acid load (DAL) is attributed to lower blood $HCO3^-$ (**Ikizler et al., 2016**).

After metabolism, the alkaline diet is believed to supply more alkaline ions (**Sherman and Gettler, 1912**). According to the acid–ash theory, in order to increase one's alkaline load and maintain a healthy lifestyle, one should eat a diet high in fruits and vegetables and low in protein (**Fenton and Huang, 2016**). In an investigation of these diet adjustments, systemic pH was only changed by 0.014 units, whereas urine pH raised by 1.02 units (**Buclin et al., 2001**).

It is proposed that an alkaline-based diet account for 80% of the diet, with acid-forming items serving for 20%, and a sodium-to-potassium ratio of 1:3. More than 60% of the diet should be alkaline-forming foods, and 40% of the diet should be acid-forming foods for a healthy lifestyle (**Sangma et al., 2019**).

Another dietary pattern associated to reduce blood pressure is the Dietary Approaches to Stop Hypertension (DASH) diet (**Savica et al., 2010**). The DASH diet limits sodium consumption to 2,300 milligrammes per day than a regular diet, which can contain up to 3,400 mg of sodium per day.. The DASH diet appears to have a natriuretic effect (**Filippou et al., 2020**), and interacts with the renin–angiotensin–aldosterone system, causing vascular and hormonal responses that contribute to hypotension (**Maris et al., 2019**).

According to Sacks et al. (2001), the DASH diet reduced blood pressure by nearly 3-fold in those who consumed additional sodium. Reduced sodium levels in the diet were thought to prevent potassium's hypotensive impact, while elevated potassium or calcium levels in the DASH diet countered this effect.

Sodium-restrictive diets like DASH as well as alkaline-based diets have been thought to improve clinical results in HF patients (**Mahtani et al., 2018**). As a result, the current study aimed to distinguish the therapeutic efficacy of DASH and alkaline-based diets on clinical outcomes of cardiac patients, including homeostatic electrolytes, lipid profiles, and systolic and diastolic profiles.

Subjects and Methods

An intervention case-control study was conducted on one hundred hypertensive cardiac adult patients of both genders from February to June 2021. The participants were recruited from the outpatient clinic of Shebien El-Kom Teaching Hospital in Menoufia Governorate, General Organization of Teaching Hospitals and Institution, Ministry of Health, Egypt. All cases were diagnosed under the supervision of a cardiovascular specialist.

Inclusion criteria: Uncontrolled hypertensive adult patients of both genders with elevated lipid and hypertensive profiles could participate in this study. **Exclusion criteria**: Patients were excluded from the study if they had other chronic diseases as diabetes mellitus, renal and hepatic; because each type of this disease need to a therapeutic special diet. Also, smoking, pregnant or lactating women.

Ethical considerations

Present study was approved by the head of out-patient clinics of Shebin El-kom Teaching Hospital. A written consent form was assigned from each participant after being provided a detailed description in plain of terms; as well each participant has a right to withdrawal from the study when he/she want any time.

Study Design

Each patient that fit the study's criteria was given a full overview of the methodology in simple terms before being signed with their informed written consent and assigned randomly to one of the experimental groups as follow:

Control Group: include fifty participants only prescribed their conventional supervised antihypertensive medications without dietary management.

Study groups (No=50) divided into:

DASH group: involve twenty-five patients were received their standard hypertension medicines as well as a dietary intervention based on the DASH diet.

Alkaline group: involve twenty-five patients were received their standard hypertension medicines as well as a dietary intervention based on the alkaline diet.

The nutritional intervention of the therapeutic diets was implemented and followed by the study groups for 21 consecutive days.

Tools of the study:

Tool I: Interview questionnaire; divided into two partitions; sociodemographic and medical data including; age, gender, participant's educational level, also marital status, monthly income, smoking habit, hypertension history, as well the convestional medicines.

Tool (II): Questionnaire for alkaline-based diet (24 hour recall form); assessing planned alkaline diets before and after nutritional intervention.

Tool (III): Physiological parameters**;** consisted of first section; blood pressure measures; second section; anthropometric measures, such as weight, height, BMI (**WHO, 2004**). While, third section; biochemical analysis including serum lipid profiles triglycerides (**Fossati, 1982**), total cholesterol (**Thomas, 1992**), low density and high density lipoproteins (**Grodon and Amer, (1977); Lee and Nieman, 1996**). Urinary pH and serum electrolytes including calcium, potassium, and sodium were determined according to **Walker et al., (1990)** using atomic absorption schmatosu, Tokyo, Japan. Bicarbonate ($HCO3^-$) was determined by direct method described by **Rispens et al., (1966)**.

Nutritional Intervention consists of six stages as follows:

Stage (1) Interviewing and assessment

After obtaining the consent to participate in this study, each participant was interviewed and fulfilled his/her structured interviewing questionnaire to collect personal and medical baseline data., which consumed around 20-30 minutes, caring for Covid-19 lock down instructions, across precautionary instructions for Ministry of Health, Egypt.

Stage (2) Dietary consumption analysis

Initially before beginning of present dietary management trial and modulation of daily routine, the food intake of each patient was recalled for three days per week by twenty-four hours recall form **(Freedman et al., 2017)**, then estimated the patients' nutritive values of the consumed foods using computer software of Food Analysis Computer Program **(Food Analysis Computer Program "FACP", 1995)**, while adequacy of sodium and potassium estimated according to food and nutrition board **(Institute of Medicine "IOM", 2005a)**, respecting the recommended dietary allowances (RDA) and adequate intakes (AI) were 1500 and 4700 mg per day for sodium and potassium according to the international guidelines of Institute of Medicine of the National Academies, Food and Nutrition Board (IMNA-FNB), **(IMNA-FNB, 2005a,b)**.

Stage (3) computing nutritional requirements

The total energy requirements were computed using the Institute of Medicine's Estimated Energy Requirement (EER) formulae (**IOM, 2005b**) based on previously gathered data from patients (age, weight, height, and degree of physical activity).

All participants received recommendations on their individual daily caloric intake based on their basal metabolic rate and their activity level.

The equations were;

- **Men (≥19 years)**

EER = [662 – (9.53 X age (yrs.)] + PA* X [(15.91 X wt (kg) + (539.6 X ht (m)]

- **Women (≥19 years)**

EER = [(354 – (6.91 X age (yrs.)] + PA* X [(9.36 X wt (kg) + (726 X ht (m)]

EER: Estimated energy requirement; **wt**: weight; **ht**: height; **PA**: Physical activity coefficient.

The adequacies of macro and micronutrients were determined using the dietary reference intake (**Dietary Reference Intakes**

"DRI", 2002); consisting of 50–60% carbohydrates, 25–30% fat, and 15–20% protein of total daily calories.

Stage (4) Meal planning

The meals call for a certain number of servings daily from various food groups. The required number of servings may vary, depending on how many calories patient need per day.

Seven meals were designed based on six-food exchange menu **(Marcus, 2013; Mahan and Raymond, 2017)**, of 2000 calories per whole day include breakfast, lunch, dinner and snacks, which repeated weekly for two times. The 2000-calorie menu was recommended as an ideal dietary intake for normal BMI value to maintain it, as well advised for whom were overweight even obese individuals, to reach a healthy weight.

Alkaline diet

The diets designed based on DRI of macronutrients, as well saturated fat less than 10%, cholesterol 150 mg/day, sodium not more than 1500 mg; these amounts include all sodium eaten, including sodium in food products as well as added through cooking with or add at the table, potassium approximately 4700 mg/day, fiber 30g (**DRI, 2005**).

A planned alkaline meals, plus in between snacks found to reinforce individuals to eat extra vegetables, fruits even drinking extra water. Furthermore, alkaline diet planned essentially to contain three up to five alternatives of vegetables per day with variety (dark green leafy vegetables, red or orange vegetables, legumes and seeds, starchy vegetables etc.), which advised to administer high-acid fruits or tomatoes that actually help to make easily humans` body more alkaline in an effective dietary modulation to manage their PH values (**Sangma et al., 2019**).

Move and above, fruit alternatives involved in alkaline food exceeds the four types (the best of which are citrus fruits, apples, berries), even their alkaline juices could manage bodies' PH, in the same line, alternatives from cereals or starches counted six sorts per day, mainly focused on complex carbohydrates with extra fiber content, such as whole grains and brown rice) as well meat alternatives were 5.5, even if preferring animal protein sources over plant-based ones, so eating red meat does not exceed once a week, in the amount of 60 grams per meal or eggs, chicken or turkey breast <3 times per week, also, eating fish high in omega-3 content twice per week **(Dietary Guidelines for Americans, 2020-2025)**.

DASH diet

The diets planned as guidelines of DRI of macronutrients, besides saturated 10%, cholesterol 150 - 200 mg/day, sodium 1500- 2300 mg, potassium 4700 mg/day, fiber 30g (**DRI, 2005**).

According to current guidelines, a planned DASH meals, plus in between snacks found to reinforce individuals to eat plenty of non-starchy vegetables and fruit, with moderate portions of fat-free or low-fat dairy products, whole grains, lean meats, poultry, beans, soy foods, legumes, and eggs and egg substitutes, fish, nuts and seeds, heart-healthy fats, such as olive and canola oil or avocados. Cutting back on dairy, desserts, and animal protein items like hot dogs, hamburgers, ready-to-eat processed meat...etc., as well as simple carbs like candies, cookies, and white rice. Also, foods high in saturated fats such as full- fat dairy, fatty meals, tropical oils, and most packaged snacks **(Filippou et al., 2020)**.

Stage (5) Implementation phase

The researchers attended the medical outpatient clinic one day per week. One hundred patients were recruited over a period of five months, and randomly allocated into equal groups study and control; according to Covid-19 lock down instructions. During the first meeting of each patient, the researchers fill out the questionnaire. Later, researchers collected and ensured each participant` medical history, anthropometric measures, and laboratory investigations` results as well the clinical measures of blood pressure. Previously, an illustrative brief colored guide booklet in simplified Arabic language approved (content relevance, clarity as well feasibility), by expert dieticians was prepared to be introduced to study group populations.

Each participant in study groups has received an Arabic colored booklet guide, where the researchers explaining the theoretical content of the booklet and giving them a listed meals with alternatives scheduled within seven days; along whole day dietary intake also were stressed on adherence to such meals along three consecutive weeks of current study to achieve the aim of the study, in addition to given instructions and recommendations to be implemented before leaving Hospital outpatient clinic, while they were ensuring their physicians given laboratory investigations request to brought in the next week.

In second week, the patients brought their laboratory results and same previous measures were done, recorded, tabulated same like previous one. As well, study group was alerted to adhere same duties during next two weeks, also repeated all mentioned procedures in the third week.

Stage (6) Evaluation and follow up:

The designed DASH or alkaline-diet (the dietary intervention continued along three weeks, as well evaluated throughout four times; first pre-intervention; second follow up after one week (post1-intervention), then the third follow up (post2-intervention); fourth one week later (post 3-intervention), in addition, comparing of both groups was done.

Statistical analysis:

Data were coded, tabulated and transformed into a specially designed format suitable for computer feeding. All entered data were verified for any errors. Data were analyzed using statistical package for social sciences (SPSS) version 25 windows and were presented in tables. Chi-square analysis was conducted, paired sample t test between pre and post intervention, ANOVA and LSD between control and study groups, as well mean and standard deviations were computed. P-value at 0.05 was used to determine significance.

Results

Socio-demographic data of study subject are shown in Table 1. The participants were distributed randomly on the study groups, 54% female and 46% male. Their mean age was categorized into 3 intervals; half of cardiac patients' aged more than 50 years old, and 80% married. Regard to their social level, in spite of 34% of them had post graduate education, the monthly income range between 3000 to 5000 Egyptian pound. While 33% are smoking.

Table (1). Socio-demographic characteristics of study participants in percentage

		Control group		DASH group		Alkaline group		p-value
		Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	
Gender	Male	17	34	18	72	11	44	0.424^{NS}
	Female	33	66	7	28	14	56	
Age categories	30-39	9	18	7	28	4	16	0.002**
	40-49	19	38	6	24	5	20	
	≥50	22	44	12	48	16	64	
Marital status	Married	40	80	19	76	21	84	0.000***
	Divorced	4	8	--	--	1	4	
	Widowed	5	10	5	20	3	12	
	Single	1	2	1	4	--	--	
Patient's education level	Primary	5	10	1	4	4	16	0.005*
	Secondary	17	34	3	12	9	36	
	University	11	22	11	44	5	20	
	Post graduate	17	34	10	40	7	28	
Monthly income	700 - 1500	3	6	--	--			0.000***
	< 1500 - > 3000	10	20	5	20	5	20	
	<3000 -5000	32	64	15	60	16	64	
	More than 5000	5	10	5	20	4	16	
Smoking habit	Smoked	12	24	11	44	10	40	0.001**
	Non-Smoked	38	76	14	56	15	60	
Duration of hypertension		5.80±2.18^{ab}		6.68±2.41^{b}		7.28±2.59^{bc}		0.032*

The significant differences are considered at the levels 0.05 (*), 0.01 (**), & 0.001 (***).

As shown in table 2, the study's line medications for cardiac patients are displayed. The findings revealed that all patients were prescribed hypertension and calcium blockers, and that diuretics were used by 48 percent of the control group, whereas diuretics were used by 4 and 12 percent of the DASH and Alkaline groups after dietary intervention, respectively.

Table 2. Line of medical management of cardiac patients

Line of medical management	Control group			DASH group			Alkaline group		
	Pre.	Post1	Post2	Pre.	Post1	Post2	Pre.	Post 1	Post 2
One antihypertension drug + beta blocker + calcium channels	13 (26%)	12 (24%)	11 (22%)	9 (36%)	19 (76)	10 (40%)	3 (12%)	4 (16%)	5 (20%)
Two antihypertesion medication + direutic + beta blocker + calcium channels	18 (36%)	23 (46%)	24 (48%)	15 (60%)	4 (16%)	1 (4%)	12 (48%)	11 (44%)	3 (12%)
Three antihypertensive drug + direutic + beta blocker + calcium channels	7 (14%)	10 (20%)	10 (20%)		1 (4%)		8 (32%)	1 (4%)	
Two antihypertensive medication + beta blocker + calcium Channels	12 (24%)	5 (10%)	5 (10%)	1 (4%)	1 (4%)	10 (40%)	2 (8%)	9 (36%)	7 (28%)
Lowered the prescribed ordered medications						4 (16%)			10 (40%)

The condition of edema in the lower limb of cardiac patients was shown in Table 3. Before the nutritional intervention, it was found that all patients' edema rates had risen, with rates as high as 60% in the alkaline group. After the first week of following the dietary intervention, the proportion of edema in the dash and alkaline groups reduced by up to 8 and 18%, respectively, whereas the percentage of infected in the control group remained unchanged. After two and three weeks of dietary intervention with dash and alkaline, no edema appeared. The incidence rate in the control group was 38 and 54 percent, respectively.

Table (3). Proportions of lower limb edema at different intervals throughout study phases

		Control group		DASH group		Alkaline group		P -value
		Freq.	%	Freq.	%	Freq.	%	
Pre intervention	No	23	46	10	40	4	16	0.733NS
	To some extent	23	46	3	12	6	24	
	Yes	4	8	12	48	15	60	
1st week	No	15	30	11	44	5	20	0.000***
	To some extent	29	58	12	48	16	64	
	Yes	6	12	2	8	4	16	
2nd week	No	14	28	13	52	12	48	0.009*
	To some extent	17	34	12	48	13	52	
	Yes	19	38	--	--	--	--	
3rd week	No	14	28	25	100	18	72	0.000***
	To some extent	9	18	--	--	7	28	
	Yes	27	54	--	--	--	--	

The significant differences are considered at the levels 0.05 (*), 0.01 (**), & 0.001 (***).

Table 4 shows that there are no statistically significant variations in anthropometric measurements between study groups. Body weight did not differ substantially across study groups and controls, with DASH, alkaline, and control groups ranging from 75.32±5.15, 75.24±6.63 to 73.08±7.21, respectively. The DASH and alkaline groups had mean BMI values of 27.48±0.97 and 26.41±1.46, respectively, which classified them as overweight.

The control group's average age is 47.38 ± 6.46, whereas the DASH and an alkaline groups' average age are 46.64±7.70 and 49.60 ± 7.31 years old.

Table (4). Anthropometric measurements of cardiac patients participating in the study

		Control group	DASH group	Alkaline group	P -value
Age (year)		47.38±6.46[a]	46.64±7.70[a]	49.60±7.31[a]	NS
Body Weight (kg)	Pre	72.88±6.95	79.20±7.75	78.28±5.13	
	Post	73.08±7.21[a]	75.24±6.63[a]	75.32±5.15[a]	NS
Sig.		0.159NS	0.000***	0.000***	
Height (cm)		165.12±6.93[a]	168.72±6.87[b]	165.52±6.06[ab]	NS
BMI (kg/m^2)	Pre	26.74±2.20	27.79±1.93	28.56±1.03	
	Post	26.81±2.31[ab]	26.41±1.46[b]	27.48±0.97[ac]	NS
Sig.		0.171NS	0.000***	0.000***	

The significant differences are considered at the levels 0.05 (*), 0.01 (**), & 0.001 (***).

Throughout the post-intervention phases, there is a statistically significant difference (P≤0.001) between the examined groups in terms of systolic and diastolic blood pressure profiles and heart pulse rate, as indicated in table 5. The study group's arterial blood pressure ratings were considerably lower than the control group after following the alkaline and DASH diets. The mean values of systolic and diastolic blood pressure are (130.40±4.98 vs. 134.00±5.40) and (83.40±6.73 vs. 83.80±4.84), for the DASH and alkaline groups respectively. The DASH (78.04±5.54) and alkaline (77.40±5.26) groups had more regular heart pulse rates after the intervention, with no significant differences compared to the control group.

Table (5). Comparative between DASH and alkaline based diet on systolic and diastolic BP among cardiac patients'

Parameters		Control group	DASH group	Alkaline group	P -value
Systolic BP	Pre	150±8.39	146.80±5.75	146.80±5.18	0.084[NS]
	Post	137.10±7.56[a]	134.00±5.40[ab]	130.40±4.98[b]	0.000***
Sig		0.000***	0.000***	0.000***	
Diastolic BP	Pre	98.10±4.62	97.20±5.78	95.60±6.34	0.171[NS]
	Post	93.30±2.96[a]	83.40±6.73[b]	83.80±4.84[b]	0.000***
Sig		0.000***	0.000***	0.000***	
***Heart pulse rate**	Pre	101.70±2.81	104.88±3.21	103.72±3.23	0.177[NS]
	Post	91.32±5.33[a]	78.04±5.54[b]	77.40±5.26[b]	0.000***
Sig		0.000***	0.000***	0.000***	
Duration of hypertension		5.80±2.18[ab]	6.68±2.41[b]	7.28±2.59[bc]	0.032*

* 70 beats per minute (bpm) is considered normal in healthy adults (**Nunan et al., 2010**).

The significant differences are considered at the levels 0.05 (*), 0.01 (**), & 0.001 (***).

In terms of lipid profiles and lipoproteins as illustrated in table 6, the improvement after intervention was found to have highly statistically significant differences (P ≤ 0.001) in the DASH and alkaline groups, whereas no statistically significant differences were found for all lipid profile variables in the control group, those who only received conventional medicine and a regular diet. Likely, for the study groups, the results shows that TG and TC did not differ significantly between DASH and alkaline groups at means (146.00±7.36 and 144.40±6.01) and (186.60±6.07 and 184.00±6.61) versus 183.40±10.37 and 219.60±10.14 for control group, respectively. In aspects of lipoproteins, HDL increased significantly after nutritional intervention, with no differences between DASH and alkaline diet at mean (64.76 ± 3.45 vs. 65.36 ±2.56), whereas LDL decreased significantly with a high significant difference between alkaline and control groups after intervention (97.92±3.08 vs 133.42±5.52), respectively.

Table (6): Comparative between DASH and alkaline based diet on lipid profile among cardiac patients'

Lipid profiles		Control group	DASH group	Alkaline group	P -value
Triglyceride (TG) mg/dl	Pre	189.28±13.56	190.08±14.21	190.08±13.98	--
	Post	183.40±10.37[a]	146.00±7.36[b]	144.40±6.01[b]	0.000***
Sig.		0.000***	0.000***	0.000***	
Total cholesterol (TC) mg/dl	Pre	224.70±11.58	232.88±6.67	223.68±11.92	--
	Post	219.60±10.14[a]	186.60±6.07[b]	184.00±6.61[b]	0.000***
Sig.		0.000***	0.000***	0.000***	
HDL (mg/dl)	Pre	41.22±4.17	39.32±0.80	40.64±4.21	--
	Post	42.32±4.58[a]	64.76±3.45[b]	65.36±2.56[b]	0.000***
Sig.		0.002**	0.000***	0.000***	
LDL (mg/dl)	Pre	137.02±5.79	135.48±4.79	138.96±6.76	
	Post	133.42±5.52[a]	101.60±7.09[b]	97.92±3.08[c]	0.000***
Sig.		0.000***	0.000***	0.000***	

HDLc: High Density lipoproteins, LDLc: Low density lipoprotein.

The significant differences are considered at the levels 0.05 (*), 0.01 (**), & 0.001 (***).

Table 7 depicts the physiological equilibrium of blood electrolytes and urine pH. It is clear that sodium levels were reduced by a mean of 135.08 ±2.02 and 134.20± 1.56 (mEq/L) in individuals who followed the DASH or alkaline diets, respectively. Potassium and calcium levels were considerably higher ($P \leq 0.001$) after following the nutrition intervention. In terms of all prior electrolytes, there is no substantial difference between the DASH and alkaline groups. In terms of blood bicarbonate, the results show that acidosis was reduced considerably ($P \leq 0.001$) after nutritional intervention with an alkaline diet vs. a DASH diet, with mean values of 28.91±1.75 and 26.21±1.54, respectively, compared to 23.29±2.26 (mEq/L) in the control group. Urinary pH was altered considerably ($P \leq 0.001$) in the same time line of the DASH and alkaline groups (8.68±0.25 vs. 8.47±0.17).

Table (7). Comparative between DASH and alkaline-based diet on the homeostatic balance of blood electrolytes and urinary pH among cardiac patients'

Serum electrolytes		Control group	DASH group	Alkaline group	P -value
Sodium (Na) (135 and 145 mEq/L)	**Pre**	139.44±4.85	137.08±1.99	137.44±1.01	
	Post	138.20±5.21[a]	135.08±2.02[b]	134.20±1.56[b]	0.013*
Sig.		0.002**	0.000***	0.000***	
Potassium (K) (3.6 to 5.2 mmol/L)	**Pre**	4.22±0.76	3.50±0.26	3.43±0.25	
	Post	4.33±0.78[a]	3.77±0.144[b]	3.74±0.18[b]	0.000***
Sig.		0.001**	0.000***	0.000***	
Calcium (Ca) (8.6-10.3 mg/dL)	**Pre**	8.28±0.19	8.12±0.23	8.25±0.36	
	Post	8.46±0.16[a]	9.11±0.31[b]	9.18±0.32[b]	0.000***
Sig.		0.000***	0.000***	0.000***	
Serum Bicarbonate ($HCO3-$) (23 to 30 mEq/L)	**Pre**	23.35±2.42	22.98±2.23	23.58±2.45	0.666[NS]
	Post	23.29±2.26[a]	26.21±1.54[b]	28.91±1.75[c]	0.000***
Sig.		0.904[NS]	0.000***	0.000***	
Urinary pH*	**Pre**	4.78±0.89	5.20±0.67	5.21±0.54	
	Post	5.10±1.03[a]	8.68±0.25[b]	8.47±0.17[b]	0.000***
Sig.		0.000***	0.000***	0.000***	

* mEq/L : milliequivalents per liter ; mmol/L: millimoles per liter; mg/dL :milligramme per décilitre. *The American Association for Clinical Chemistry set the normal urine pH range is between 4.5 and 8 (**AACC, 2019**). The significant differences are considered at the levels 0.05 (*), 0.01 (**), & 0.001 (***).

Table 8 shows the dietary intake of macronutrients and consumption ratio of minerals among cardiac patients. The intention of the alkaline and DASH diets has been to control sodium, protein, and calories in attempt to optimize the condition of hypertension in cardiac patients. Before the nutritional intervention, the average energy intake was more than the nutritional requirements of the patients, while it was decreased after following the DASH or alkaline meals with very high significant differences ($P \leq 0.001$), at a mean of 2462.36 ± 144.71 and 2168.87 ± 86.34, respectively. Also, there was a significant difference between the two groups, with a greater decrease in the alkaline group. For protein intake, there was no difference between pre and post intervention in the DASH group (108.35±14.07 vs. 104.48±8.52 g/day); while it was limited significantly in the alkaline group (88.93±6.47 vs. 79.99±6.65 g/day) respectively. Regarding dietary sodium intake, there was a huge significant difference ($P \leq 0.001$) between the DASH and alkaline diets, with more restrictions in the alkaline group (1609.68±281.63 mg/day) when compared to the DASH group (2660.02±145.29) mg/day, whereas the daily food intake for the control group was 8719.24±820.23 mg/day. At the same time, potassium intake was modified in both the DASH and alkaline groups, with more equilibrium in the last group (4385.72±520.15 mg/day) with a highly significant difference ($P \leq 0.001$) after nutritional intervention. For Na/K ratio, the alkaline group had the most optimising ratio (2.92±0.70) which differed significantly ($P \leq 0.001$) from the DASH (1.36±0.22) or the control group (4.21±1.27).

Table 8: Dietary intake of calories, protein and sodium-potassium ratio of cardiac patients'

Dietary intake		Control group	DASH group	Alkaline group	P-value
Total calories (kcal/day)	Pre	2723.33±121.76[a]	2629.88±122.24[a]	2721.79±125.98[a]	0.988
	Post	2745.30±113.81[a]	2462.36±144.71[b]	2168.87±86.34[c]	0.000
Sig.		0.407[NS]	0.000***	0.000***	
Protein intake (g/day)	Pre	124.28±8.81[a]	108.35±14.07[b]	88.93±6.47[c]	0.000
	Post	116.47±8.77[a]	104.48±8.52[b]	79.99±6.65[c]	0.000
Sig.		0.000***	0.156[NS]	0.000***	
Sodium (mg/day)	Pre	8702.55±816.58[a]	8700.89±844.31[a]	8753.74±843.95[a]	0.940
	Post	8719.24±820.23[a]	2660.02±145.29[b]	1609.68±281.63[c]	0.000
Sig.		0.117[NS]	0.000***	0.000***	
Potassium (mg/day)	Pre	1833.64±570.39[a]	2507.27±786.86[b]	2610.81±737.13[b]	0.000
	Post	2281.05±729.87[a]	3623.66±557.47[b]	4385.72±520.15[c]	0.000
Sig.		0.005*	0.000***	0.000***	
Na/K ratio	Pre	5.15±1.48[a]	3.79±1.23[b]	3.77±1.17[b]	0.000
	Post	4.21±1.27[a]	1.36±0.22[b]	2.92±0.70[c]	0.000
Sig.		0.004**	0.000***	0.003**	

The significant differences are considered at the levels 0.05 (*), 0.01 (**), & 0.001 (***).

Discussion

The purpose of this study was to investigate the therapeutic efficacy of DASH and alkaline-based diets on the clinical profiles of cardiac patients.

The reduction of contractility associated with an acidosis is determined by the fall of pH in the intracellular fluid. Most systemic arterial capillaries contract as a result of metabolic acidosis, lowering peripheral resistance. Conversely, the immediate vascular impact is counteracted by the increased sympathoadrenal activity generated by acidosis. Low pH reduces the responsiveness of peripheral arteries to both alpha and beta-adrenergic stimulation (**Mitchell et al., 1972**). DASH and alkaline-based diets, have been advocated to achieve better health outcomes in cardiac patients and their conditions such as hypertension, high blood lipids, and obesity by shifting dietary choices to more "alkaline" alternatives, thereby preventing severe complications **(Remer and Manz, 1994)**.

According to the results, 39 percent of the subjects had just a high school education. Prior literature has correlated low parental educational status to increased sodium consumption in adults, implying that they are more prone to consume more sodium, perhaps contributing to hypertension development. This hypertension, diabetes mellitus (DM), dyslipidemia, coronary artery disease, stroke, anaemia, and a history of smoking were all proven significantly more prevalent in those with lower educational attainment. Overall, these findings indicate that a person's educational level is directly related to their medical difficulties.

The current study found that arterial blood pressure ratings of cardiac patients were significantly lower after following the alkaline or DASH diets; this finding was agreement with the predictions of **Carnauba et al., (2017), Krupp et al., (2018), and Daneshzad et al., (2019)**, who discovered a positive statistically significant association between dietary acid load (DAL) and hypertension.

Hydrogen ions compete with calcium for binding to the cardiac protein troponin, as **Katz, (1970)** explain in detail. The inhibitory effect of troponin on actin-myosin interaction must be overcome in order for crossbridges between actin and myosin to be created, ATP to be broken down, and contraction to occur. Calcium ions, secreted from the sarcoplasmic reticulum with each action potential, increase mechanical contraction by binding to troponin and counteracting its inhibitory effect. When intracellular H+ concentrations are high, a fewer fraction of the intracellular Ca may react with troponin, fewer actin-myosin interactions occur, and contraction intensity is weakened (**Blanchard and Solaro, 1984**).

The hypothesis that metabolic acidosis caused by a western diet high in acidogenic foods (meat, fish, and cheese) and low in alkaline foods (vegetables, fruits, and legumes) obstructs the absorption of minerals that lower blood pressure, could explain the association between acid–base imbalance and high blood pressure (**Rylander et al., 2009**). High DAL levels may increase calcium and magnesium excretion in the urine, as well as cortisol release, resulting in a decrease in citrate excretion while there is an inverse relationship between intracellular potassium concentration and citrate excretion (**Daneshzad et al., 2019**). In order to maintain volume and tonicity, potassium loss causes compensatory sodium increases in cells, worsening hypertension. Furthermore, systemic metabolic acidosis may elevate blood pressure by increasing cortisol release and lowering citrate excretion, leading to cardiometabolic disorders (**Trinchieri et al., 2013)**.

For human life to survive, a pH level in the bloodstream of roughly 7.4 (a slightly alkaline range of 7.35 to 7.45) is recommended (**Waugh and Grant, 2007**). Urine pH can fluctuate from acid to alkaline depending on the need to harmonize the internal environment. The current study revealed that by following a dietary intervention with an alkaline diet vs. a DASH diet, acidosis was significantly decreased. Both the DASH and alkaline groups had considerable changes in urinary pH. Maintaining K+ homeostasis appears to be dependent on the low sodium high potassium (LNaHK) diet's capacity to create an alkaline load.

The fact that an alkaline LNaHK diet, which yields systemic $HCO3^-$, stimulates a high rate of K^+ secretion while sustaining the K^+ balance. Reabsorbing NaCl is effectively substituted for secreted KHCO3 in an LNaHK diet that induces an alkaline load (**Nanami et al., 2015**). The ratio of K^+ secretion to Na^+ reabsorbed in the distal nephron is substantially higher than 2:3 and may be as high as 3:1 (**Wen et al., 2014**).

The current results were corroborated by **Hottenrott, et al., (2020)**, who found that alkaline supplementation enhanced plasma HCO3- concentration and urine pH while also preventing acidosis. Maintaining K^+ homeostasis appears to be dependent on the LNaHK diet's capacity to create an alkaline load. **Cornelius et al., (2016)** published a literature review in the American journal of renal physiology in 2016, highlighting three major concurrent factors associated with the LNaHK diet that are responsible for maintaining K^+ balance: the first is dietary anionic content, which is responsible for creating an acidic or alkaline load for the kidneys. The role of high plasma ANG II (P[ANGII]) and plasma aldosterone (Aldo) concentrations is the second (P[Aldo]). Increased plasma levels of K^+ boost Aldo production in the adrenal glomerulosa when a high-K diet is taken (**Christensen et al., 2010**). Furthermore, when the Na^+-K^+-ATPase is activated with a high P[K+], the intracellular Na^+ concentration is kept low (**Peti-Peterdi et al., 2002**). The final topic is the origins and consequences of high distal flow. The protective effects of increased K^+ on blood pressure may be due to this natural diuretic impact (**Todkar et al., 2015**).

Correction of acidosis with bicarbonate (**Frassetto et al., 2001**) or potassium citrate (**McSherry and Morris, 1978**) leads to a large rise in growth hormone and improve the quality of life, lower cardiovascular risk factors, improve body composition, and even improve memory and cognition (**Wass and Reddy, 2010**). Meanwhile, **Appel et al. (1997)** found that a fruit and vegetable-based diet, termed DASH diet, decreased blood pressure in hypertensive participants in a longitudinal trial.

Improvements in lipid profiles and lipoproteins after intervention were found to be statistically significant in both the DASH and alkaline groups ($P \leq 0.001$). Furthermore, HDL levels increased drastically after dietary intervention, with no differences between the DASH and alkaline diets, whereas LDL levels decreased considerably, with a significant difference between the DASH and control groups.

The review of **Ostrowska, et al., (2020)** support the current findings, which found the strongest interaction between lipid metabolism and DAL. Acidosis is caused by high rates of lipolysis, β-oxidation, and CoA synthesis, which results in ketone formation and a transitory loss in buffering capacity. According to **Hood and Tannen (1998),** an acidic environment has been demonstrated to limit triglyceride release from adipocytes, and as a result, acidosis may contribute to weight loss inhibition.

Many researches have proven a link between LDL-C, total cholesterol, and DAL values (**Bahadoran et al., 2015; Han et al., 2016; Farhangi et al., 2019**). Furthermore, **Kucharska et al. (2018)** indicate that the proportion of hypertriglyceridemia was considerably greater in the highest NEAP category, suggesting that it might be related to increased cortisol and insulin excretion as a result of administering a high acid-forming potential diet. The significant decline in blood cholesterol levels can be attributed in part to a decrease in circulating fatty acids and glucose, as well as an increase in dietary fiber content, which is considered to slow the progression of cardiac hypertrophy and fibrosis, as well as overall decreased cardiac function, as seen in HF patients, according to **Rifai et al., (2015)**. High-density lipoprotein (HDL-C) had an inverse, statistically significant correlation with DAL, indicating that its much greater concentrations were attributed to the lowest DAL. Furthermore, alkaline supplementation during fasting boosted ketogenesis and ketoacid excretion, exhibiting higher fat mobilization, according to Hood et al. (1982) . Also, the reasoning of the **(Hottenrott et al., 2020)** consistent with the findings of the current study, which found that alkaline nutrient supplementation improved fat loss in fasting participants and that increasing alkaline element consumption increased fat loss.

The study found that adopting an alkaline or Dash diet lowered sodium levels while significantly increasing potassium and calcium levels. According to **Rifai et al., (2015)**, the DASH diet has been found to successfully decrease blood pressure and provides therapeutic effects for patients with heart failure. According to **Abu-Sawwa et al., (2019)** the DASH diet emphasizes the consumption of fruits and vegetables, lean protein such as poultry, fish, and nuts, fiber and whole grains, and low-fat dairy products in order to maintain appropriate amounts of micronutrients assumed to reduce blood pressure, such as potassium, calcium, and magnesium.

The influence of the DASH diet on HF outcomes in people with cardiovascular disease has been studied in the early stages. DASH diet has been shown to promote arterial elasticity, ventricular diastolic function, ventricular-arterial elastance coupling, and overall arterial stiffness **(Rifai and Silver, 2016)**. Blood pressure and 24-hour urine sodium levels were both reduced after following a DASH diet, and quality of life improved. Endothelial dysfunction, which is a proxy for HF disease development, is embodied by the inverse relationship between deficits in nitric oxide-mediated vasodilation, the inflammatory cytokine cascade, and free radical generation, which is embodied by the DASH diet's beneficial effect on arterial elasticity and ventricular diastolic function. Delivered DASH meal consumption over four weeks decreased symptoms and functional status, according to a recent randomized controlled trial by **Hummel et al., (2018)**.

Conclusion

The study concluded that acidosis was significantly decreased, HDL levels increased with no significant differences between the DASH and alkaline diet. Furthermore, as compared to the control group, cardiac pulse rates were more regular following the intervention, and arterial blood pressure ratings were much lower. The alkaline diet has the greatest homeostatic impact on blood electrolytes, since there are no significant variations in blood lipids between it and the dash diet.

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التأثير التوازني للنظام الغذائي القلوي و وجبة الداش على الكتروليتات الدم ومؤشرات الدهون بمرضى القلب: دراسة مقارنة

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الملخص: مرضى قصور القلب الاحتقاني عادة ما يظهرون اضطرابات في قلوية و حموضة الدم، بسبب تنشيط العديد من الآليات العصبية والأدوية المستخدمة في هذه الحالة ، مثل مدرات البول. يظهر حوالي 37٪ على الأقل من المرضى الذين يعانون من قصور القلب الاحتقاني اضطرابا في القاعدة الحمضية للدم. مما يؤدي الحموضة الدموية إلى إطلاق الكاتيكولامينات، والتي تخفف من التأثير المؤثر في التقلص العضلي السلبي على انقباض القلب والتأثير التوسعي الوعائي المحيطي بسبب انخفاض درجة الحموضة في السائل داخل الخلايا. لقد ثبت أن الحموضة الأيضية تحفز الفازوبريسين وهرمون الغدة الكظرية والألدوستيرون ، وبالتالي قد يزيد من ضغط الدم. ثبت أن الحميات القلوية و الداش قد تحقق نتائج صحية أفضل لمرضى القلب عن طريق تحويل الخيارات الغذائية إلى بدائل أكثر "قلوية" ، وبالتالي منع حدوث مضاعفات خطيرة. الهدف الدراسة الحالية هو دراسة الفعالية العلاجية لوجبة الداش والوجبات الغذائية المعتمدة على القلوية على المؤشرات السريرية لمرضى القلب.

الطريقة: تم إجراء دراسة مقارنة بالتدخل الغذائي على مائة حالة من مرضى القلب البالغين الذين يعانون من ارتفاع ضغط الدم ، وتم تقسيمهم إلى مجموعة ضابطة؛ و مجموعة وجبة الداش ومجموعة الوجبة القلوية اتبعوا الأنظمة الغذائية العلاجية لمدة

21 يومًا متتاليًا. ثم تم حساب المتطلبات الغذائية والاستهلاك الغذائي. تقييم إلكتروليتات الدم، ضغط الدم، مؤشرات الدهون في الدم ودرجة الحموضة في البول. **النتائج:** طوال فترات ما بعد التدخل ، لوحظ ان انخفاض الصوديوم ذات دلالة إحصائية ($P\leq0.001$) مع اتباع النظام الغذائي القلوي بدلاً من نظام DASH الغذائي ، في حين ارتفع معدل البوتاسيوم والكالسيوم ($P\leq0.001$). عدلت درجة الحموضة في البول بشكل كبير في كل من مجموعات DASH والحمية القلوية ، بينما تحسن ضغط الدم الانقباضي والانبساطي ($P\leq 0.001$) مع عدم وجود فروق معنوية. **الخلاصة:** خلصت الدراسة إلى أن حموضة الدم انخفضت بشكل كبير بعد التدخل الغذائي باتباع الحمية القلوية مقارنة بالنظام الغذائي الداش.

الكلمات المفتاحية: الحمية القلوية ، الصوديوم ، الكالسيوم ، البيكربونات ، الحموضة الأيضية.