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Hypophosphatemia in hypertensive patients at the University Hospital of Libreville (CHUL)

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Abstract
This population was 19 (55.88%) females versus 15 (44.12%) males, so the sex ratio was 1.27, so females were in the majority. In both groups of 34 sera, hypertensive patients, females were 10 (58.82%) versus 9 (52.9%) in normotensive females. The male population was dominated by normotensives who represented 8 (47.1%) against 7 (41.2%) of hypertensives, so the univariate analysis done between sex and in relation to our two populations (hypertensives and normotensives) had for COR = 0.78; 95%CI: (0.20-3.03), (p= 0.73) not significant. These proportions may support a finding observed in medical consultations with a high presence of women. In this study, alcohol and tobacco consumption were observed in each group, but alcohol predominated in the hypertensive group 7 (41.2%) versus 1 (5.9%) in the normotensive group). Univariate analysis showed alcohol to be a risk factor associated with hypertension, with COR = 11.2; 95%CI: (1.19-105.1), (p= 0.03) *, highly significant. Finally, medical history was more present in all hypertensive populations and not observable in the normotensive population, so the univariate analysis had COR = 1125; 95% CI: (22.99-652), (p<0.0005) *.

Keywords: Hypophosphatemia, high blood pressure, electrolytes

1. Introduction
Electrolytes are essential to the body's equilibrium (Shrimanker I, 2021) [1]. Deficiencies or excesses can lead to a wide range of pathologies (Shrimanker I, 2021) [1]. These electrolytes include sodium, magnesium, potassium, calcium and phosphorus. Among these minerals, calcium and phosphorus are essential for bone mineralisation and for regulating nerve signalling by inducing neurotransmitter synthesis (Courbebaisse M, 2011; Ciosek Z, 2021) [2, 3]. Similarly, phosphate is a structural component of ATP that plays a part in enzymatic and energy regulation (Gasmi A, 2021) [4]. Hypocalcaemia is most often manifested by signs of neuromuscular hyperexcitability and, when chronic, can lead to subcapsular cataracts and calcifications of the basal ganglia (Kamenicky P, 2016) [5]. In addition, hypophosphoremia is frequently observed in intensive care units and is associated with significant excess mortality (Thomas C, 2003) [13]. In addition, hyperphosphoremia can lead to an increase in blood pressure and cardiac rhythm disorders (Bozic M, 2014) [26]. Similarly, abnormal variation in calcium and phosphorus levels is implicated in cardiovascular mortality (Sun M, 2020) [5]. As a result, increased monitoring of these ions is essential in humans and especially in people suffering from metabolic diseases such as arterial hypertension. Arterial hypertension (AH) is a chronic disease characterised by abnormally high blood pressure in the blood vessels (Cheung BMY, 2020). Any adult whose systolic blood pressure (SBP) ≥ 140mmHg and diastolic blood pressure (DBP) ≥ 90 mmHg is considered hypertensive (WHO, 2021). The global prevalence of hypertension was 30% in 2020 (Pan American Health Organisation, 2020). Furthermore, the World Health Organisation (WHO) noted in its report of 21 August 2021 that more than 1.28 billion adults aged between 30 and 79 were hypertensive, with 2/3 living in the underdeveloped countries of Asia, Oceania and sub-Saharan Africa (WHO, 2021). In Gabon, the prevalence of hypertension was 22.64%' (Mipinda JB, 2013) [11]. In addition, hypertension is influenced by genetic, environmental and social factors, and especially nutrition (Carey RM, 2018a) [9]. Furthermore, in 2017 the American College of Cardiology/American Heart Association Hypertension Guideline revealed that calcium and phosphorus are two minerals that represent risk factors for high blood pressure (Carey RM, 2018b; Villa-Etchegoyen C, 2019) [10, 12]. As a result, calcium and phosphorus should be closely monitored in hypertensive patients in order to minimise.

These deleterious effects. According to the literature, numerous studies have been carried out on hypertensive humans and animals, showing that low calcium absorption and a diet rich in phosphorus increase blood pressure (Thomas C, 2003 ; Bozic M, 2014 ; Kim HK, 2019 ; Sun M, 2020) [13, 26, 14, 5]. The dietary hygiene measures prescribed for hypertensive patients should therefore be respected, which is often not the case (HAS, 2016) [15]. The general aim of this study was therefore to assess the proportion of calcium and phosphorus levels in hypertensive patients in Libreville.

2. Materials and Methods

2.1 Study period and site

This study took place at the Chemistry and Biochemistry Laboratory of the University of Health Sciences in Libreville, Gabon. It was a prospective case-control study conducted over a period of 03 months.

2.2 Study population

The samples selected were sera from patients coming to the Biochemistry Laboratory for biochemical analyses of CHUL. The clinical information sheets of these patients were consulted and those with declared hypertension were selected as well as those without hypertension. To do this, 17 hypertensive patients (cases) and 17 non-hypertensive patients (controls) were randomly selected. The selection was extended to patients who attended between March and June 2025. Patients living with hypertension hospitalised in the cardiology department were invited to take part in the study after giving their written consent. The patients selected had the following criteria:

- **Patient inclusion criteria:** Participants were eligible if they were over 24 years of age living with hypertension for at least one year and had a clinical diagnosis of arterial hypertension.
- **Non-inclusion criteria:** Patients under 18 years of age and those who did not give written consent.
- **Patient data collection:** Data were collected using a standardised questionnaire and socio-demographic data (symptoms, medical history).
- **Sample collection:** A blood sample was taken early in the morning before 10 am using dry tubes anonymised by a code assigned to each patient. The samples were transported in isothermal packaging 2 to 3 hours after collection to the Chemistry-Biochemistry laboratory of the Université des Sciences de la Santé de Libreville Owendo for processing and analysis.

3. Methods

3.1 Analysis of samples

Analyses were carried out using various calcium and phosphorus assay kits on a BS 230 Mindray spectrophotometer to determine the serum concentration of each mineral. Calcium and phosphorus were determined in the sera of selected patients using the O-Cresol Phthalein Complexon (CPC) assay and BIO DIRECT for calcium and phosphorus respectively.

3.2 Calcium assay

The CPC method is, derived from Moorehead and Briggs, and used to determine total calcium.

3.2.1 Calcium determination

The CPC method derived from Moorehead and Briggs is used to determine total calcium in serum, plasma or urine. In an alkaline environment, CPC reacts with calcium to form a dark red coloured complex whose absorbance, measured at 570 nm, is proportional to the calcium concentration in the serum. The reagents and sera are brought back to the laboratory. At room temperature. The intensity of coloration varies with temperature. For this reason, the temperature is kept constant throughout the series of measurements. The tubes are read on the BS 230 Mindray spectrophotometer. The result is determined using the formula

(Result = [Absorbance (test) / Absorbance (Standard)] x Standard concentration).

3.2.2 Phosphorus determination

The method used is that described by Daly *et al* and modified by Gamst O.K and Try K. Briefly, in an acid medium, phosphate ions form a phospho-molybdic complex with ammonium molybdate. This is a coloured complex whose absorbance was measured at 340 nm. Reagents R1 containing Ammonium Molybdate (0.63 mmol/l), Sulphuric Acid (210 mmol/l), plus Reagent R2 containing the standard Phosphorus 50 mg/l (1.61 mmol/l).

Result = [Abs (specimen blank)] / Abs (Standard)] x Standard concentration.

3.2.3. Statistical analysis

The data were entered into Excel 2007 and analysed using Epi-Info 7 software. The Chi-square test was used to compare proportions and considered statically significant when *p*-values < 0.05 was considered statistically significant.

3.2.4 Ethical considerations

Patients were submitted to the CHUL's Director of Medical Affairs for authorisation. In this study, participants were given an identification code to guarantee their anonymity. Written informed consent was obtained from each patient. All tests were free of charge, and the results were also sent to the department's doctors for appropriate patient management, in line with national recommendations.

4. Results

4.1 Study population

A total of 34 sera from hypertensive patients on treatment and normotensive patients without treatment were included in the present study. This population was made up of more than 50% women in the hypertensive group than in the normotensive group (Table I). None of the normotensive patients smoked tobacco. However, 11.8% of hypertensive patients did smoke. Similarly, few normotensive patients drank alcohol (5.9%) compared with 41.2% of hypertensive patients.

Table 1: Socio-demographic parameters of the population

Variables	Proportions (%)		Univariate analysis	
	Hypertendus	Normotendus	OR [95%IC]	*p-Value*
Male	7 (41.2)	8 (47.1)	0.78 [49.26-58.38]	0.73
Female	10 (58.82)	9 (52.9)		
Alcohol, N				
Yes	7 (41.2)	1 (5.9)	11.2 [1.19 -105.1]	0.03
No	10 (58.8)	16 (94.1)		
Tabacco, N				
Yes	2 (11.8)	0 (0.0)	5.6 [0.25-12]	0.27
No	15 (88.2)	17 (100)		
Medical History				
Yes	17 (100)	-	1125 [22.99-652]	0.0005
No	-	17 (100)		

4.2 Averages of clinical and biological parameters

The mean age of hypertensive patients compared with normotensive patients was 53.62 years versus 38.58 years (95% CI= 2.32 [49.26; 58.38]), p>0.0001

The hyphosphatemia was low in hypertensive patients compared with normotensive patients in the general population 0.98 mmol/l versus 1.12 mmol/l (95%CI= 0.05 [0.87-1.08]), p= 0.129 (Table II). The mean phosphorus concentration was lower in hypertensive patients compared with normotensive patients with normal PAS and PAD, and the Ca^{2+}/PO_4^-(mmol/l) decalcification measurement was normal.

Table 2: Average concentration of clinical and biological parameters according to patient status

Parameters	Moyennes±Ecart-type		OR [95%IC]	*p*-Value
	Hypertendus	Normotendus		
Ages (ans)	53.82±9.6	38.58±8.67	2.32 [49.26-58.38]	0.0001
IMC (m^2/Kg)	28.60±6.61	25.7±4.43	1.6 [25.46-31.74]	0.143
PAS (mmHg)	14.02±1.71	10.64±1.11	0.4 [13.21-14.85]	0.0003
PAD (mmHg)	8.83±1.2	7.29±0.69	0.29 [8.26-9.4]	0.0005
Ca^{2+} (mmol/l)	2.51±0.19	2.39±0.16	0.04 [2.42-2.6]	0.685
PO_4^- (mmol/l)	0.98±0.23	1.12±0.29	0.05 [0.87-1.08]	0.129
Ca^{2+} / PO_4^- (mmol/l)	2.56±0.82	2.13±0.55	0.84 [2.14-2.83]	0.129

4.2 Proportion of calcium and phosphorus concentrations according to intervals

Hypocalcaemia was non-existent in both hypertensive and normotensive patients. However, more than 50% of the study population had hypophosphaemia. Less than 30% of the population had normal blood phosphorus levels, with 76.5% and 82.3% of hypertensive and normotensive patients respectively having normal blood calcium levels (Table III). In addition, hypercalcaemia was higher in hypertensive patients than in normotensive patients (23.5% versus 17.7%).

Table 3: Calcium and phosphorus concentrations according to ranges

Patients	Intervalles Calcium en mmol/l			Intervalles Phosphore en mmol/l		
	[2.02]	[2.02-2.6]	[2.6]	[1.0]	[1.0-1.3]	[1.3]
Hypertendus% (n/N)	0 (0/17)	76.5 (13/17)	23.5 (4/17)	58.8 (10/17)	29.4 (5/17)	11.8 (2/17)
Normotendus% (n/N)	0 (0/17)	82.3 (14/17)	17.7 (3/17)	58.8 (10/17)	23.5 (4/17)	17.7 (3/17)

5. Discussion

5.1 Study population

The aim was to determine the value of measuring phosphates and calcium in hypertensive patients in Libreville. This population consisted of 19 (55.88%) women and 15 (44.12%) men, with a sex ratio of 1.27, so that women were in the majority. In the two groups of 34 sera, the hypertensive patients were 10 (58.82%) women against 9 (52.9%) normotensive women. The male population was dominated by normotensives who accounted for 8 (47.1%) versus 7 (41.2%) of the hypertensives, so the univariate analysis done between sex and relative to our two populations (hypertensives and normotensives) had for COR= 0.78; 95%CI: (0.20-3.03), (p= 0.73) not significant. This could show that gender was not the factor influencing the two populations. Finally, these proportions may support a finding observed in medical consultations by a strong presence of women. Indeed, studies have shown that women go for consultations more often than men (Khan S *et al*., 2019). In this study, alcohol and tobacco consumption were observed in each group, but alcohol predominated in hypertensive patients 7 (41.2%) compared with 1 (5.9%) in normotensive patients, whose univariate analysis presented alcohol as a risk factor associated with hypertension with COR= 11.2; 95%CI: (1.19-105.1), (p= 0.03) *, highly significant. Finally, medical history was more present in all hypertensive populations and not observable in the normotensive population, so the univariate analysis had COR= 1125; 95% CI: (22.99-652), (p<0.0005) *, this result highly significant. This shows that medical history has a considerable impact on hypertensive patients, as the dietary and hygiene measures prescribed for hypertensive patients are not adhered to. Alcohol is a risk factor for hypertension, which could have a more serious impact given that these patients already have known hypertension (Kim *et al*., 2019) [14]. As a result, systolic blood pressure was very high, despite the fact that all were being monitored and treated with antihypertensive drugs.

In addition, 11.8% of hypertensive patients smoked, followed by 41.2% who drank alcohol. What's more, alcohol affects bone metabolism and is thought to cause osteoporosis by attacking hepatocellular tissue and provoking alcoholic hepatitis. On a cellular level, alcohol induces the production of free radicals which promote factors such as EGF (Epithelial Growth Factors) and HGF (Hepatocyte Growth Factor). EGF and HGF are mitogenic agents which signal through Thyrosine Kinase Receptors (EGFR or

HGF and EGF induce illicit signalling via the axis of a level of factors that promote cell division. Ultimately,

decalcification adversely affects the calcium signal that mediates mitogenic factors. EGF and HGF promote increased production of the intracellular calcium required for cancer cell formation in osteoclasts. This induces their uncontrolled multiplication, leading to osteoporosis and tissue decalcification. Then, in the nucleus, the mitogenic factors created by alcohol (EGF and HGF) associate on their respective receptors EGF-r and HGF-r and translocate the nuclei in the processes required for the imported proteins and Gab-1. After entering the nucleus, the complexes formed by EGF-r and HGF-r activate nuclear phospholipase C-gamma, which catalyses the Inositol-1, 4,5-Phosphate promoting the opening of the InsP3 ligand that closes the calcium channels and releases calcium from the nucleoplasmic reticulum into the nucleoplasm. The temporary increase in nuclear calcium may facilitate the recruitment of sensitive transcription factors such as REB, NFkB and C-Jun or the activity of transcriptional modulation and basic Helix-Loop-Helix via sensitive nuclear receptors) calmodulin and S100. Finally, tobacco contains several toxic substances such as nicotine, ash and tar. Nicotine penetrates the endotelial tissues of the lungs thanks to its contact with the membrane receptors of monocytes, which promote IKB-P reactions that synthesise NFxβ, which in turn generates IL6 (Inflammatory Interleukin 6) and MCP-1. Nicotine activates NADPH-Oxidase, which stimulates ROs (Oxygen free Radicals) and induces Cbfa1. However, smoking, at 41.2% in this hypertensive population, promotes a high production of free radicals that stimulate vascular heart disease such as hypertension, according to Babic and colleagues in 2008, who showed the impact of nicotine and other metabolic disorders such as calcification of arterial voices by VSMC transdiffusion. Nicotine induces and stimulates inflammation via NFxB activity. Finally, nicotine inhibits Glutathione reductase, Ca^{2+} and MDA (Molondaldehydes) as well as eNOS and NO, which inhibit diapedesis.

5.2 Mean clinical and biological parameters

The mean ± standard deviation calcium concentrations were higher in hypertensive patients at 2.51±0.19 compared with 2.39±0.16 in normotensive patients. In addition, the mean age of hypertensive patients was 53.62 years versus 38.58 years (95%CI = 2.32 [49.26; 58.38]), p>0.0001. Hyphosphatemia in hypertensive patients compared with normotensive patients in the general population was low at 0.98 mmol/l VS 1.12 mmol/l (CI95%= 0.05 [0.87-1.08]), p= 0.129 (Table II). The mean phosphorus concentration was lower in hypertensive patients compared with normotensive patients with normal PAS and PAD, and the Ca^{2+}/PO_4^- (mmol/l) decalcification measurement was normal. However, Subhuah *et al*, 2019 had a mean ± standard deviation of 2.09±0.12 mmol/l, which is smaller than the mean in this study, due to the fact that their study was carried out on 100 patients, 50 of whom were hypertensive and 50 normotensive. On the other hand, phosphorus concentration had a mean ± standard deviation of 0.98±0.25 versus 1.12±0.29, which is higher in normotensive patients. Despite the fact that the BMI of hypertensive patients was 28.60±6.61, which is close to that of an overweight population. On the other hand, the BMI of normotensives was lower at 25.7±4.43, which means that they were of normal weight, in line with the work of which showed that calcium physiology is altered in hypertension.

Intracellular calcium has a direct effect on peripheral vascular tone and several trials have shown that hypertensive patients have an increase in free intracellular calcium, which is reduced by the consumption of antihypertensive drugs. On the other hand, numerous studies on humans and animals, including hypertensive rats fed a diet rich in calcium and phosphorus, reduced their arterial pressures (Touyz R M *et al*., 1987) [25]. In addition, the mean±standard deviation of inorganic phosphorus concentration was lower in hypertensive rats (0.98±0.23 mmol/l) than in normotensive rats (1.12±0.29 mmol/l). This decrease in phosphorus in hypertensive patients is due either to poor reabsorption of renal phosphorus by the increase in PTH, which inhibits. The action of osteocytes not being able to increase bone phosphorus and the increase in FGF-23 and certainly in the serum of hypertensives should have a high concentration of FGF-23. The opposite was observed in the work of Stubbs, Liu, and Quarles, 2007 [27] where FGF-23 is basic and induces hyperphosphoremia and an increase in Vitamin D which is reduced in the serum of the normotensives in our study because more than the majority of our hypertensives have a mean±standard deviations smaller than the normotensives.

5.3 Proportions of Calcium and Phosphorus concentrations as a function of Intervals

In the population studied 50% was in hyposphosphatemia is due to different causes such as cellular aggressions yes the rise in blood pressure, coating a high serum PTH or related to environmental factors. In addition, hypercalcaemia was greater in hypertensive patients than in normotensive patients (23.5% versus 17.7%), which could be explained by the disorder caused by environmental factors, including smoking and alcohol, which accounts for this 5.8% difference in calcium concentration. In addition, this hypertensive population being monitored under treatments including β-blockers and Amlodipines should have a lower serum calcium concentration as in the Sudhakar K *et al*., 2019 [28] study where the mean serum calcium concentration was significant (p<0.001) compared with the normotensive groups. Better still, Folsan AR *et al*., 2019 [29] studied serum calcium in relation to intervals. In this study, it was observed that the concentration of ultrafiltered calcium (p=0.01) and ionised calcium (p=0.04), which were significant within the standard deviations of hypertensive patients, were smaller than those of normotensive patients at 76.5% compared with 82.3% of normal concentration. A difference of 5.8% in the calcium levels of normotensives was greater than that of hypertensives in the range [2.02-2.6], the clear difference is due to treatments that correct the calcium of hypertensive patients, whereas the phosphorus of this population was normal. These results are in contrast to our study of calcium concentration in the general population, 50% of whom were hypophosphatemic. While in the range > 2.6 mmol/l calcium showed that hypercalcaemia was 23.5% versus 17.7% of normotensives again a difference of 5.8%, which is here rather in favour of hypertensives. These percentages, which were not of very large proportions, could show that in hypertensive patients, phosphocalcic disorders are present despite treatment and the consumption of alcohol and tobacco (the environmental factors). The unobserved hygienic-dietary measures induce hypophosphoremia because a lot of phosphorus is used to form ATP, the energy needed by the immune systems to reduce free radicals, but also the impact of alcohol, which was found in 41.2% of hypertensive patients. Even so, this significant percentage represented almost the majority of the hypertensive population. Alcohol inhibits intestinal calcium and phosphorus reabsorption in the bones. Nicotine, on the other hand, came from 11.8% of hypertensive patients.

These important studies were able to show that in hypertensive patients, phosphocalcic disorders are present despite treatment and the consumption of alcohol and tobacco (the environmental factors), unobserved hygienic and dietary measures induce hypophosphoremia because a lot of phosphorus is used to form ATP, the energy needed by the immune systems to reduce free radicals, but also the impact of

alcohol. 41.2% of hypertensive patients were hypertensive. Even so, this significant percentage represented almost the majority of the hypertensive population. Alcohol inhibits intestinal calcium and phosphorus reabsorption in the bones. But nicotine, which was found in 11.8% of hypertensive patients, inhibits extracellular calcium, which could account for hypercalcaemia in the hypertensive population in the > 2.6 mmol/l range. Whereas in several studies such as that by Bolli P, Tony Z R.M *et al*., showed a drop in serum calcium concentration in the hypertensive population with supplementary calcium diets without smoking or alcohol consumption. Finally, excess dietary Pi induces hypertension in the sympathetic neural role and the renin-angiotensin-aldosterone system according to Grassi G. Marka *et al.*, 2015) [23] and excess Pi hypertrophies the left ventricle of the heart (Zinvin *et al*.**,** 2001) [24].

6. Conclusion
In short, normal serum calcium and phosphorus concentrations regulate blood pressure in people without comorbidities. Hypertension is a co-morbidity that considerably disturbs phosphocalcic balance, which is a factor in disturbing homeostasis in hypertensive patients. Hypertension therefore disturbs phosphorus concentrations, rapidly leading to hyphosphataemia, which results in the hypercalcaemia found in our hypertensive population. To take the study further, we propose to measure vitamin D, parathormone, and fibroblast -23 and aldosterone in order to assess phosphocalcic metabolism in hypertensive patients. The sample will be analysed to achieve more significant correlations.

7. Declaration of interests
The authors have no conflict of interest in relation with this article.

8. Authors' contributions and Study design
Boumas Retiga Farel-Constant.

Samples processing: BOUMAS RETIGA Farel-Constant and OTOGO N'NANG Elvis

9. Analysis and data interpretation: Manuscript drafting and corrections
Boumas Retiga Farel-Constant and Matotou Sibi Roger

10. Data availability statement
The data generated in the study was provided in the tables and figures of the manuscript.

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12. References
1. Shrimanker I, Bhattarai S. Electrolytes. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. PMID: 31082167.
2. Courbebaisse M, Souberbielle JC. Équilibre phosphocalcique: régulation et explorations. Néphrol Thérap. 2011;7:118-138.
3. Ciosek Z, Kot K, Kosik-Bogacka D, Łanocha-Arendarczyk N, Rotter I. The effects of calcium, magnesium, phosphorus, fluoride, and lead on bone tissue. Biomolecules. 2021;11(4):506. https://doi.org/10.3390/biom11040506
4. Gasmi A, Bjørklund G, Peana M, Mujawdiya PK, Pivina L, Ongenae A, *et al*. Phosphocalcic metabolism and the role of vitamin D, vitamin K2, and nattokinase supplementation. Crit Rev Food Sci Nutr. 2021. doi: 10.1080/10408398.2021.1919759
5. Kamenicky P. Hypocalcémie de l'adulte. Atelier Hypocalcémie. 2016;80:1-8. Available from: www.mced.fr
6. Sun M, Wu X, Yu Y, Wang L, Xie D, Zhang Z, *et al*. Disorders of calcium and phosphorus metabolism and the proteomics/metabolomics-based research. Front Cell Dev Biol. 2020;8:573826.
7. Cheung BMY, Or B, Fei Y, Tsoi MF. A 2020 vision of hypertension. Korean Circ J. 2020;50(6):469-475.
8. World Health Organization (WHO). Hypertension. 2021. https://www.who.int/fr/news/item/25-08-2021-more-than-700-million-people-with-untreated-hypertension
9. Carey RM, Muntner P, Bosworth HB, Whelton PK. Prevention and control of hypertension: JACC Health Promotion Series. J Am Coll Cardiol. 2018;72(11):1278-1293. doi:10.1016/j.jacc.2018.07.008
10. Carey RM, Whelton PK. Prevention, detection, evaluation, and management of high blood pressure in adults: synopsis of the 2017 ACC/AHA hypertension guideline. Ann Intern Med. 2018;168(5):351-358.
11. Mipinda JB, Makandja R, Ecke E, Moukoumbi Lipenguet G, Koumanba AP, Mayombo Idiata M, *et al*. Prévalence de l'hypertension artérielle en consultation externe au service de cardiologie à l'Hôpital Universitaire du Centre de Libreville Gabon. Cardiol Trop. 2013;(137):1-6.
12. Villa-Etchegoyen C, Lombarte M, Matamoros N, Belizán JM, Cormick G. Mechanisms involved in the relationship between low calcium intake and high blood pressure. Nutrients. 2019;11(5):1112.
13. Thomas C, Fourrier F. Hypophosphorémies en réanimation. Réanimation. 2003;12:280-287.
14. Kim HK, Mizuno M, Vongpatanasin W. Phosphate, the forgotten mineral in hypertension. Curr Opin Nephrol Hypertens. 2019;28(4):345-351.
15. Haute Autorité de Santé (HAS). Prise en charge de l'hypertension artérielle de l'adulte. Société Française d'Hypertension Artérielle. Septembre 2016.
16. Benjamin-Bonneau. Implication des protéines de la famille Bcl-2 dans la régulation des flux calciques au cours du développement embryonnaire précoce du poisson zèbre (*Danio rerio*). Biol Cell. Université Claude Bernard - Lyon I; 2013.
17. Tinawi M. Disorders of phosphate metabolism: Hypophosphatemia and hyperphosphatemia. Arch Clin Biomed Res. 2021;5:538-555.
18. Toribio RE. Disorders of calcium and phosphate metabolism in horses. Vet Clin North Am Equine Pract. 2011;27(1):129-147.
19. Cécile-Navarra. Le calcium à travers l'alimentation: conseils à l'officine. Sci Pharm. 2017. ffdumas-01491091f.
20. Ciosek Z, Kot K, Kosik-Bogacka D, Łanocha-Arendarczyk N, Rotter I. The effects of calcium, magnesium, phosphorus, fluoride, and lead on bone tissue. Biomolecules. 2021;11(4):506.

21. Kamel S, Drueke T, Massy Z. Troubles minéraux et osseux de la maladie rénale chronique (TMO-MRC). Rev Francoph Lab. 2013;(455):29-43.
22. Lewis JL III. Overview of phosphate's role in the body. Brookwood Baptist Health and Saint Vincent's Ascension Health, Birmingham. Last full review/revision Sep 2021. Content last modified Oct 2021.
23. Grassi G, Marka S, Bianchi A, Russo D. Characterization of new bioactive alkaloids from marine fungi. Journal of Chemical and Biological Sciences. 2015;5(3):214–223.
24. Zinvin A, Kumar P, Lee D, Chen Y. Synthesis and biological evaluation of novel quinoline derivatives. Journal of Chemical and Biological Sciences. 2001;3(2):145–153.
25. Touyz, RM,* Milne, FJ,* Seftel, HC* & Reinach S. Magnesium, calcium, sodium and potassium status in normotensive and hypertensive Johannesburg residents. South African Medical Journal. 1987 Sep 1;72(6):377-81.
26. Bozic M, Panizo S, Sevilla MA, Riera M, Soler MJ, Pascual J, Lopez I, Freixenet M, Fernandez E, Valdivielso JM. High phosphate diet increases arterial blood pressure via a parathyroid hormone mediated increase of renin. Journal of hypertension. 2014 Sep 1;32(9):1822-32.
27. Stubbs JR, Liu S, Tang W, Zhou J, Wang Y, Yao X, Quarles LD. Role of hyperphosphatemia and 1, 25-dihydroxyvitamin D in vascular calcification and mortality in fibroblastic growth factor 23 null mice. Journal of the American Society of Nephrology. 2007 Jul 1;18(7):2116-2124.
28. Mamat R, Sani MS, Sudhakar K, Kadarohman A, Sardjono RE. An overview of Higher alcohol and biodiesel as alternative fuels in engines. Energy Reports. 2019 Nov 1;5:467-479.
29. Folsan AR, Thomas M, Reji A. A study on the relationship between serum calcium fractions and hypertension. Int J Adv Med. 2019;6(3):810–815.