Journal of Biotechnology and Bioengineering
Volume 4, Issue 4, 2020, PP 19-24
ISSN 2637-5362

The Relationship between Diabetes, Hypertension, Heart, and Kidney Diseases

Azab Elsayed Azab[1]*, Abdelsalam M. Mansour[2], Mohamed Omar Albasha[3]

[1]Department of Physiology, Faculty of Medicine, Sabratha University, Libya
[2]Department of Medical Engineering, Division of Genetic Engineering, Academy of Graduate Studies Tripoli, Libya
[3]Department of Zoology, Faculty of Science, Alejelat, Zawia University, Alejelat, Libya.

***Corresponding Author:** Azab Elsayed Azab, Department of Physiology, Faculty of Medicine, Sabratha University, Libya.*

Abstract

***Background:** Type 2 diabetes mellitus (T2DM) is commonly associated with cardiovascular disease (CVD) risk factors, such as hypertension, obesity, and dyslipidemia. Hypertension is common among patients with diabetes, with the prevalence depending on type and duration of diabetes, age, sex, race/ethnicity, body mass index (BMI), history of glycemic control, and the presence of kidney disease, among other factors.*

***Objectives:** The aim of the present study to highlight the relationship between diabetes, hypertension, and heart and kidney diseases. Obesity, metabolic syndrome, and T2DM are three interrelated conditions that share several pathophysiological mechanisms and that are frequently observed to lead, in succession, to cardiovascular complications. Obesity is recognized as a risk factor for cardiovascular disease, which produces independent adverse effects in the car¬diovascular system. Obesity induces a variety of structural adaptations of the cardiovascular system, from subclinical myocardial dysfunction to severe left ventricular systolic heart failure. Dyslipidemia associated with T2DM is typically more complex than the simple elevation of systemic low-density lipoprotein cholesterol (LDL-C) levels. Diabetes mellitus (DM) is always associated with raised triglycerides. Hypertriglyceridemia is one of the risk factors in coronary artery disease. Low plasma concentrations of high-density lipoprotein cholesterol (HDL-C), elevated levels of apolipoprotein B, and elevated triglyceride (TG) levels, as well as abnormalities in lipoprotein particle size and subclass distribution. The kidney is important in the pathogenesis of T2DM, and that kidney parameters may be useful additional markers of patients at high risk for the development of diabetes. Biochemical parameters of kidney functions were associated with a worsening in insulin action and predicts the development of T2DM. Decreased serum sodium levels are occasionally observed in patients with type 2 diabetes mellitus. Hypertension was more prevalent among males than among females. The association between hypertension and chronic kidney disease (CKD) is well known, considering that CKD is the greatest cause of secondary hypertension.*

***Conclusion:** It can be concluded that there is a close correlation between dyslipidemia, CKD, and CVD in patients with T2DM. Diabetes mellitus is a strong risk factor for CKD and CVD. All patients with T2DM must be started on primary prevention by health education, aggressive lifestyle changes, such as weight reduction and physical exercise and use of lipid-lowering drugs should go hand-in-hand with antidiabetic drugs to reduce the risk of coronary heart disease and atherosclerosis. Drug treatment is necessary for controlling these risk factors which include hypertension, dyslipi¬demia, metabolic abnormalities, and excess weight.*

Keywords: *Association, Lipid profile, Kidney function tests, Diabetes, Hypertension, Heart disease, Kidney disease.*

Introduction

Type 2 diabetes mellitus (T2DM) is commonly associated with CVD and risk factors, such as hypertension, obesity, and dyslipidemia. CVD is the most common cause of death in people with diabetes. It has been found that the presence of diabetes significantly increases the risk (two to four folds) for developing CVD [1]. Hypertension is common among patients with diabetes,

with the prevalence depending on type and duration of diabetes, age, sex, race/ethnicity, BMI, history of glycemic control, and the presence of kidney disease, among other factors [2-5]. Furthermore, hypertension is a strong risk factor for atherosclerotic cardiovascular disease, heart failure, and microvascular complications [5]. According to the study done by Preis et al. [6], it has found that T2DM is associated with clustered risk factors for CVD. Adults with diabetes have a 77%–87% prevalence of hypertension, a 74%–81% prevalence of elevated low-density lipoprotein cholesterol (LDL-C), and a 62%–67% prevalence of obesity.

It is important to mention that hypertension and dia¬betes are closely related to obesity and metabolic syndrome [7]. Obesity is recognized as a risk factor for cardiovascular disease, which produces independent adverse effects in the car¬diovascular system. This relationship is complex due to several associations with risk factors/cardiovascular disease markers such as hypertension, dyslipidemia, insulin resistance/dysglycemia, or T2DM. Obesity induces a variety of structural adaptations of the cardiovascular system, from sub clinical myocardial dysfunction to severe left ventricular systolic heart failure. Abnormalities in cardiac metabolism and later cardiac energy have been proposed as the main contributors to cardiovascular disease-related to obe¬sity. Ectopic fat deposits play an important role in several of the hypotheses postulated to explain the association between obesity, cardiac metabolism, and cardiac dysfunction [7,8].

Objectives

The present study aimed to highlight the relationship between diabetes, hypertension, and heart and kidney diseases.

Relationship between Obesity and Cardiovascular Diseases

Obesity, metabolic syndrome, and T2DM are three interrelated conditions that share several pathophysiological mechanisms and that are frequently observed to lead, in succession, to cardiovascular complications. Their prevalence is increasing alarmingly should prompt all healthcare professionals urgently to implement measures to pre¬vent these complications. The most effective, though also the least adopted, are those related to lifestyle modification. Drug treatment targeted at controlling risk factors (e.g., hypertension and dyslipi¬demia), metabolic abnormalities, and excess weight are also necessary [5, 9-12].

Diabetes Mellitus and Cardiovascular Risks

T2DM patients generally carry several risk factors for CVD, including hyperglycaemia, abnormal lipid profiles, alterations in inflammatory mediators and coagulation/thrombolytic parameters, as well as other nontraditional risk factors, many of which may be closely associated with insulin resistance [13].

Lipid profile levels can still be used in screening populations to identify the subjects with a high risk of developing cardiac events [14]. Hypertriglyceridemia is one of the risk factors in coronary artery disease and diabetes mellitus is always associated with raised triglycerides [14, 15].

Dyslipidemia associated with T2DM is typically more complex than the simple elevation of systemic low-density lipoprotein cholesterol (LDL-C) levels. The LDL-C levels seen in diabetic populations may not be significantly different from the values seen in nondiabetic populations. The high atherogenicity associated with diabetic dyslipidemia is probably related to the characteristic finding of low plasma concentrations of high-density lipoprotein cholesterol (HDL-C), elevated levels of apolipoprotein B and elevated triglyceride (TG) levels, as well as to abnormalities in lipoprotein particle size and subclass distribution [13, 16, 17]. Among the wide range of lipoprotein subclasses that have been described, disproportionate amounts of small, dense LDL particles, and small HDL particles are thought to constitute a particularly atherogenic profile due to high susceptibility to oxidation [13, 18].

Diabetic dyslipidemia was characterized by a high level of plasma triglyceride, and low-density lipoprotein concentrations with a low level of high-density cholesterol due to reduced action of insulin at the tissue level or due to insulin resistance [19, 20]. It increases the risk of atherosclerosis particularly, if glycaemic control is poor, which in turn is an important risk factor for coronary heart disease [20, 21].

Ahmida et al. [22] reported that the high prevalence of lipid disorders in Libyan T2DM in Benghazi city suggests that they might be playing a major role in the development of atherosclerosis in Libyan patients. Therefore, lipid profiling of all patients with T2DM should be a routine test. All patients with T2DM must be started on primary prevention by health education, aggressive lifestyle changes, such as weight reduction and physical exercise and use of lipid-lowering drugs

should go hand-in-hand with antidiabetic drugs to reduce the risk of coronary heart disease and atherosclerosis.

Satti et al. [23] found that increased levels of glucose, hemoglobin A1c (HbA1c), and decreased sodium level were observed among uncontrolled T2DM in Sudan, who were over 5 years since getting diagnosed with T2DM than who was on control. Decreased serum sodium levels are occasionally observed in patients with type 2 diabetes mellitus due to numerous underlying pathogenesis mechanisms especially among patients with poorly controlled DM. DM predisposes individuals to hypertension by promoting sodium retention, increasing vascular tone by contributing to nephropathy. Hypertension in T2DM can be partly a consequence of insulin resistance and hyperinsulinemia [13, 24, 25].

Association between Diabetes and Kidney Diseases Risk Factors

The study of Alam *et al.*, [26] was carried out in Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine, and Metabolic Disorders. It was observed that the mean values of total cholesterol *($p<0.001$)* and creatinine *($p<0.001$)* were significantly higher in diabetic patients than in non-diabetic patients. The fasting blood sugar correlates highly with the mean values of total cholesterol and creatinine.

Al Salhen and Mahmoud, [27] studied that the biochemical parameters of kidney functions in T2DM males and females aged 40-60 years among patients seeking medical care at the Hospital of El-Beida, Libya. 103 T2DM patients (24 females +79 males) were included in this study. 39 nondiabetic subjects (10 females + 29 males) were selected as controls. The mean ages of the diabetic patients were 56.10 ± 7.82 years. The serum urea, creatinine, uric acid concentrations (mg/dl), (47.24 ± 12.48), (1.19 ± 0.39), and (8.19 ± 2.42) were significantly ($P<0.05$) increased in diabetic patients compared with controls (28.74 ± 2.13), (0.79 ± 0.04), and (4.98 ± 0.81), respectively. The author concluded that biochemical parameters of kidney functions were associated with a worsening in insulin action and predicts the development of T2DM. These results support the hypothesis that the kidney is important in the pathogenesis of T2DM, and that kidney parameters may be useful additional markers of patients at high risk for the development of diabetes.

Belguith, [28] found that as glucose level increases, the estimated glomerular filtration rate (eGFR) decreases in diabetic patients i.e. increases the risk factor to CKD. According to sex, the author observed that males present higher eGFR values than females. More than half of the patients (55%) fall in CKD stage -2, 16% in stage-1, and 27% in stage-3. According to sex, mostly males exhibit more values than females in all stages.

Correlation between Serum Lipid Levels and Hypertension

Brown *et al*. [29] confirmed the association between several factors including BMI, serum cholesterol, HDL, and hypertension. Also, Ruixing et al. [30] reported that age, hyperlipidemia, high BMI, and sodium intake were associated with hypertension. Ghooshchi et al. [31] reported that total cholesterol (TC), TG, and LDL levels were higher in hypertensive patients in comparison with non-hypertensive individuals. Also, Choudhury et al., [32] reported that the serum levels of TC, TG, and LDL were higher while HDL levels were lower in hypertensive subjects compared to normotensives, which was statistically significant. Age and BMI showed a significant association with hypertensive patients but not with normotensives.

Relationship between Diabetes Mellitus, and Hypertension, Chronic Kidney and Heart Diseases

The main risk factors attributed to CKD are increased life expectancy, diabetes mellitus, and hypertension [33, 34]. These factors are intimately associated with the socio-economic development of a given population: On the one hand, improved living conditions and access to healthcare services reduce the number of deaths due to infections and external causes; on the other, higher quality of life can sometimes lead to a sedentary lifestyle and poorer nutritional habits. The association between hypertension and CKD is well known, considering that CKD is the greatest cause of secondary hypertension [34].

Hypertension can also determine the emergence of CKD and contribute to its progression to the terminal stage. Associations between blood pressure levels and kidney function deterioration have been shown by many research studies [34-36]. While, diabetes mellitus represents the leading isolated cause of end-stage kidney disease in several countries [34, 36].

Chikwere et al. [37] reported that the cross-sectional study, involving 100 subjects, was carried out at the diabetes centre, Komfo Anokye Teaching Hospital, Kumasi, Ghana. Of the 100 patients, 74% had high systolic blood pressure. Also, high LDL-C and hyper-

cholesterolemia were found in 47% and 46% of the patients, respectively. Forty-six percent (46%) of the patients were hyperuricaemic. Cardiovascular disease risk increased with age from 20 to 79 years. The diabetic female had more adverse CVD risk profile than the male (high LDL, 55% vs. 23.1%; high total cholesterol, 54.1% vs. 23.1%; high triglycerides, 32.4% vs. 30.8%; low HDL, 25.7% vs. 3.8%). Fifty percent (50%) of females compared to 34.6% of males were hyperuricaemic. However, hypertension was more prevalent among males (systolic blood pressure, 76.9%; diastolic blood pressure, 38.5%) than among females (systolic blood pressure, 73%; diastolic blood pressure, 37.8%).

There is a close correlation between dyslipidemia, CKD, and CVD in patients with T2DM. Diabetes mellitus is a strong risk factor for CKD and CVD. Dyslipidemia is common in diabetic patients and diabetic dyslipidemia is strongly correlated with diabetic nephropathy and CVD. The relationships between dyslipidemia, diabetic nephropathy, and CVD in T2DM patients are summarized by Chen and Tseng, [38] (Figure. 1).

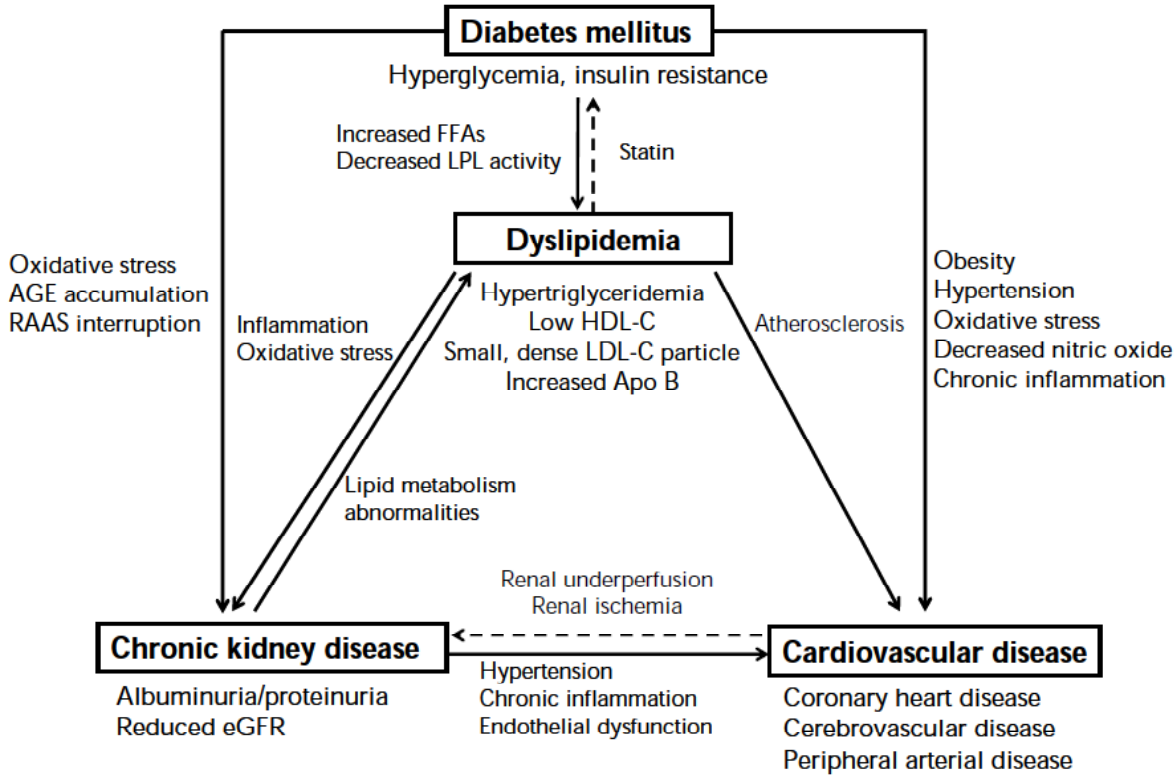

Figure1. *Relationship between dyslipidemia, chronic kidney disease, and cardiovascular disease in diabetes mellitus.*

AGE - advanced glycation end-product, Apo B - apolipoprotein B, eGFR - estimated glomerular filtration rate, FFA - free fatty acid, HDL-C - high-density lipoprotein cholesterol, LDL-C - low-density lipoprotein cholesterol, LPL - lipoprotein lipase, RAAS - renin-angiotensin-aldosterone system [38].

Conclusion

It can be concluded that there is a close correlation between dyslipidemia, CKD, and CVD in patients with T2DM. Diabetes mellitus is a strong risk factor for CKD and CVD. All patients with T2DM must be started on primary prevention by health education, aggressive lifestyle changes, such as weight reduction and physical exercise and use of lipid-lowering drugs should go hand-in-hand with antidiabetic drugs to reduce the risk of coronary heart disease and atherosclerosis. Drug treatment is necessary for controlling these risk factors which include hypertension, dyslipi¬demia, metabolic abnormalities, and excess weight.

References

[1] Barrett-Connor EL, Cohn BA, Wingard DL, Edelstein SL. (1991). Why is diabetes mellitus a stronger risk factor for fatal ischemic heart disease in women than in men? The Rancho Bernardo Study. JAMA., 265(5): 627–631.

[2] Arauz-Pacheco C, Parrott MA, Raskin P; American diabetes association. (2003). treatment

of hypertension in adults with diabetes. Diabetes Care., 26 (Suppl.1): S80–S82.

[3] De Ferranti, S. D., De Boer, I. H., Fonseca, V., Fox, C. S., Golden, S. H., Lavie, C. J., and Zinman, B. (2014). Type 1 diabetes mellitus and cardiovascular disease: a scientific statement from the American heart association and American diabetes association. Circ., 130(13), 1110-1130.

[4] Fox, C. S., Golden, S. H., Anderson, C., Bray, G. A., Burke, L. E., De Boer, I. H., and Inzucchi, S. E. (2015). Update on prevention of cardiovascular disease in adults with type 2 diabetes mellitus in light of recent evidence: a scientific statement from the American Heart Association and the American Diabetes Association. Circ., 132(8), 691-718.

[5] De Boer, I. H., Bangalore, S., Benetos, A., Davis, A. M., Michos, E. D., Muntner, P., Rossing P, Zoungas S, and Bakris, G. (2017). Diabetes and hypertension: a position statement by the American diabetes association. Diabetes care, 40(9), 1273-1284.

[6] Preis, S.R., Pencina, M.J., Hwang, S.J., D'Agostino Sr, R.B., Savage, P.J., Levy, D. and Fox, C.S., (2009). Trends in cardiovascular disease risk factors in individuals with and without diabetes mellitus in the Framingham Heart Study. Circ.,120(3):212–220.

[7] Albarracin MLG. (2018). Hypertension and diabetes: A latent problem in Colombia Inter J Card Pulmon Rehabil., 2018(1): 1-6.

[8] Piche ME, and Poirier P. (2018). Obesity, ectopic fat and cardiac metabolism. Ex¬pert Rev Endocrinol Metab 13: 213-221.

[9] Ezquerra E, Vazquez JMC, and Barrero AA (2008). Obesity, metabolic syndrome and diabetes: cardiovascular implications therapeutic action. Rev Esp Cardiol., 61: 752-764.

[10] Kim NH, Seo JA, Cho H, Seo JH, Yu JH, et al. (2016) Risk of the development of diabetes and cardiovascular disease in metabolically healthy obese people: The korean genome and epidemiology study. Med (Baltimore) 95: e3384.

[11] Albarracin MLG. (2017). Metabolic syndrome and cardiovascu¬lar implications in younger people. Therap Advan Cardiol¬.,1: 188-198.

[12] Gunturiz ML and Chaparro PE (2017). Diabetic cardiomyopathy: Cause or consequence of diabetes mellitus? Cardiol Cardio Vasc Med., 1: 155-168.

[13] Kalofoutis C, Piperi C, Kalofoutis A, Harris F, Phoenix D, and Singh J. (2007). Type II diabetes mellitus and cardiovascular risk factors: Current therapeutic approaches. Exp. Clin. Cardiol., 12(1): 17-28.

[14] Maduka IC, and Egwu MC. (2017). The relationship between alcoholism and cardiac biomarkers in non insulin dependent diabetics. Pharm. Chem. J., 4(1): 60-66.

[15] Kudchodkar BJ, Lee MJ, Lee SM, Dimrco NM, and Lacko AG. (1988). Effect of dietary protein on cholesterol homeostasis in diabetic rats. J. Lipid Res., 29: 1272-1287.

[16] Bays H. (2003). Atherogenic dyslipidaemia in type 2 diabetes and metabolic syndrome: Current and future treatment options. Br. J. Diabetes Vasc. Dis., 3: 356-360.

[17] Brunzell JD, and Ayyobi AF. (2003). Dyslipidemia in the metabolic syndrome and type 2 diabetes mellitus. Am. J. Med.,115(8A): 24S-28S.

[18] Fonseca VA. (2003). Management of diabetes mellitus and insulin resistance in patients with cardiovascular disease. Am. J. Cardiol., 92: 50-60.

[19] Lberti K.G, Bennett P, Pan X.R, Li G.W, Hu Y.H, and Wang J.X. (1997). Review follow-up report on the diagnosis of diabetes mellitus. Diab. Care, 20(7):1183-1197.

[20] Zafar E, Choudhary S, Rahman F, and Kumar R. (2016). Correlation of dyslipidemia among hypothyroidism and type II diabetes mellitus. Sch. J. App. Med. Sci., 4(12A): 4243-4248.

[21] Mooradian AD. (2009). Dyslipidemia in type 2 diabetes mellitus. Nat. Clin. Prac. Endocrinol. Metab., 5(3):150-159.

[22] Ahmida M, Gatish Z, Al-Badry S, El-Shalmani I, and El-Deeb O. (2015). Dyslipidemia in type II diabetes mellitus patients in Benghazi, Libya. Inter. J. Biomed. Advan. Res., 6(10): 749-753.

[23] Satti S, Gurashi RA, and Fadul O. (2017). Evaluation of hyponatremia among type 2 diabetes patients in Sudan. J. Med. Biol. Sci. Res., 3(1): 5-8.

[24] Cockcroft JR, Webb DJ, Wilkinson IB. (2000). Arterial stiffness, hypertension and diabetes mellitus. J. Hum. Hypertens, 14: 377-380.

[25] Aoun S, Blacher J, Safar ME, and Mourad JJ. (2001). Diabetes mellitus and renal failure: Effects on large artery stiffness. J. Hum. Hypertens,15: 693-700.

[26] Alam J, Chandra SM, and Mokarrama MN. (2015). A comparative analysis of biochemical and hematological parameters in diabetic and non-diabetic adults. Inter. J. A.M.S., 2(1): 1-9.

[27] Al Salhen, K. S., and Mahmoud, A. Y. (2016). Determinants of abnormal kidney function tests in diabetes patient type 2 in Libya. Inter J Sci Stud., 4(6): 99-103.

[28] Belguith H. (2012). Use of e-GFR formula to evaluate kidney function in diabetes mellitus patients in Al-Jouf area, Saudi Arabia. J. Biomed. Sci., 1(1-2): 1-9.

[29] Brown CD, Higgins M, Donato KA, Rohde FC, Garrison R, Obarzanek E, Ernst ND, and Horan M. (2000). Body mass index and the prevalence of hypertension and dyslipidemia. Obes. Res., 8(9): 605-619.

[30] Ruixing Y, Jinzhen W, Shangling P, Weixiong L, Dezhai Y, and Yuming C (2008). Sex differences in environmental and genetic factors for hypertension. Am. J. Med., 121(9): 811-819.

[31] Ghooshchi G, Masoomian M, Sarafraz Yazdi M, and Pour Ramezan M. (2014). Evaluation of the lipid profile of hypertensive patients compared to non-hypertensive individuals. Patient Saf. Qual. Improv., 2(3): 120-122.

[32] Choudhury KN, Mainuddin AKM, Wahiduzzaman M, and Islam SMS. (2014). Serum lipid profile and its association with hypertension in Bangladesh. Vasc. Health Risk Manag., 10: 327–332.

[33] Bakris GL, Weir MR, Shanifar S, Zhang Z, Douglas J, van Dijk DJ, and Brenner BM (2003). Effects of blood pressure level on progression of diabetic nephropathy: results from the RENAAL study. Arch. Intern. Med., 163(13): 1555-1565.

[34] De Pinho NA, de Oliveira RCB, and Pierin AMG. (2015). Hypertensive patients with and without kidney disease: assessment of risk factors. Rev. Esc. Enferm. USP, 49: 99-106.

[35] Bloomfield GS, Yi SS, Astor BC, Kramer H, Shea S, Shlipak MG, and Post WS. (2013). Blood pressure and chronic kidney disease progression in a multiracial cohort: the Multi-ethnic study of atherosclerosis. J. Hum. Hypertens, 27(7):421-426.

[36] Sesso RCC, Lopes AA, Thomé FS, Lugon JR, Watanabe Y, and Santos DR. (2014). Report of the Brazilian chronic dialysis census 2012. J. Bras. Nefrol., 36(1): 48-53.

[37] Chikwere P, Nsiah K, and Tandoh MA. (2015). Hyperuricaemia and other cardiometabolic risks among type 2 diabetes patients. Trends J. Sci. Res., 2(4): 126-133.

[38] Chen S and Tseng CH. (2013). Dyslipidemia, kidney disease, and cardiovascular disease in diabetic patients. Rev. Diab. Stud.,10(2-3): 88-100.

Citation: *Azab Elsayed Azab, Abdelsalam M. Mansour, Mohamed Omar Albasha. The Relationship between Diabetes, Hypertension, Heart, and Kidney Diseases. Journal of Biotechnology and Bioengineering. 2020; 4(4): 19-24.*