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EDITORIAL

In treating diabetes, what is important? Glucose levels or outcome measures?

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Abstract

Gaps in knowledge prevail in recognizing which glycemic parameters to order and in determining glycemic control. However glycosylated hemoglobin (HbA1c) is most commonly ordered to determine glycemic control. HbA1c provides information of overtime glycemic control but does not inform post meal glycemic excusions. The latter may be significant in outcome measure such as cardiovascular disorder (CVD), renal failure or amputation in diabetes. In order to obviate the dilemma in the importance between fasting blood glucose (FBG) and 2-h post prandial glucose (2hPPG), we innovated delta (d) which is the difference between 2hPPG minus FBG. There is much information available relating 2hPPG or postprandial hyperglycemia to CVD and some information relating 2hPPG to renal failure or amputation. Thus much emphasis is laid upon glycemic control with little or no emphasis on the complications of diabetes or the outcome measures. The focus of this editorial is to draw attention to outcome measures by ordering fasting and 2-h postprandial (2hPP) basic metabolic panel (BMP) which provides glucose levels, renal function test and electrolytes. HbA1c significantly relates to 2hPPG, thus by ordering F and 2hPP BMP instead of HbA1c alone will serve both purposes: Glycemic control and outcome measure. Delta (d) glucose (dhPPG-FBG) is a stronger predictor than 2hPPG of renal function deterioration.

Key words: Diabetes; Outcome measures; Amputation; Renal failure; Glycosylated hemoglobin; Postprandial hyperglycemia; 2-h postprandial glucose

Core tip: Postprandial glucose level (2-h after major meal: Breakfast or lunch) is the cornerstone of laboratory test for diabetes to monitor glycemic control and prognosticate development or progression of diabetic

complications.

Mandal AK. In treating diabetes, what is important? Glucose levels or outcome measures? *World J Diabetes* 2015; 6(13): 1243-1245 Available from: URL: http://www.wjgnet.com/1948-9358/full/v6/i13/1243.htm DOI: http://dx.doi.org/10.4239/wjd.v6.i13.1243

INTRODUCTION

Lowering of blood glucose levels to normal or near normal levels in diabetes mellitus is a legitimate consideration. But why and which glycemic parameters are to follow in therapeutic strategy. There are three glycemic parameters to consider: Glycosylated hemoglobin (HbA1c), fasting blood glucose (FBG) and 2-h postprandial blood glucose (2hPPG). The latter is obtained after a major meal or by oral glucose tolerance test. There are valid reports in the literature to suggest that lowering of blood glucose to normal levels with intensive insulin therapy will prevent microvascular complications[1,2]. The pitfalls of previously published reports are that no information is provided which glycemic parameters were used to determine outcome. However FBG and HbA1c were most commonly used in outcome studies. There is no indication that 2hPPG was used to monitor prevention or progression of microvascular complications. Author orders FBG and 2hPPG in all patients with diabetes prior to their office visits. HbA1c is ordered quarterly which is permitted by health insurance. 2hPPG is the pivotal glycemic marker for author's studies. We initially observed that elevation of blood glucose ⩾ 200 mg/dL (⩾ 11.1 mmol/L) or even ⩾ 50 mg/dL above FBG at 2-h postprandial (2hPP) period is associated with a discerning increase of serum creatinine (Scr) and a proportionate decrease of estimated glomerular filtration rate (eGFR) when sampled on the same day. The above renal function changes are less noticeable when 2hPPG is less than 200 mg/dL or difference between 2hPPG-FBG called dglucose is less than 50 mg/dL. Renal function change is easily noticeable when d glucose is above 100 mg/dL. Here is a brief example to that effect (Table 1).

Thus with delta (d) glucose of 121 mg/dL, increase of Scr and decrease of eGFR are very noticeable. He was being treated with metformin and Lisinopril. These medication were discontinued and he was placed on Glargine insulin (Lantus®), subcutaneously 15 units after breakfast and 15 units after dinner. He is also hypertensive; hypertension is kept under control with spironolactone and chlorthalidone. His 24 h Urine total protein was less than 111 mg. Close to two years later his blood pressure is 120/60 mmHg and his 2hPPG is decreased to 191 mg/dL (10.8 mmol/L) and renal function improved with decrease of Scr from 1.28 mg/dL to 1.17 mg/dL and increase of eGFR from 58 to 59 mL/min. In his subsequent office visit, renal function is stable or better.

The greatest pitfall in Advance Trial and many similar trials using oral anti diabetic agents is the renal outcome defined by diabetic nephropathy. This is an unmeaningful way to determine the renal outcome. Nephropathy defined clinically as the presence of microalbuminuria is a common complication of type 2 diabetes. There was no mention whether any renal function tests were done in the assessment of nephropathy in Advance trial or other clinical trials. Thus the serious deficiency in the assessment of significant risk reduction of nephropathy in Advance Trial is the lack of use of renal function test such as Scr or GFR in defining nephropathy[3]. It should also be noted that many subjects with diabetes are also hypertensive; hence proteinuria can result from diabetic or hypertensive nephropathy. Thus, without kidney biopsy, it would be most difficult to determine cause of proteinuria whether due to diabetes or hypertension. Renal biopsy was seldom done in outcome studies.

In our studies, renal function test as already defined is the mirror of glycemic control. Our goal is to determine the staging of diabetes-related chronic kidney disease (CKD) by the available eGFR and treat them with a combination of insulin therapy to determine if progression of CKD into end stage renal disease can be halted.

In Advance trial, intensive glucose control had considerable renoprotective effects compared with standard control, with 21% risk reduction ratio for new or worsening nephropathy. The component of nephropathy that was clearly reduced was macroalbuminuria (risk reduction ratio of 30%; 0 < 0:001).

The purpose of this editorial is to reveal which glycemic parameters are most predictive of renal function changes.

We already reported that delta (d) glucose (2hPPG-FBG) relates significantly to renal function changes. For every 100 mg/dL increase in dglucose, dScr increases by 0.11 mg/dL and d eGFR decreases by 3.73 mL/min. Thus dglucose is a stronger predictor of renal function than 2hPPG[4].

Our current study is an expanded study and for a longer duration. All patients are treated with a combination of Glargine (Lantus®) or detemir insulin twice daily after breakfast and dinner and one of the regular or fast acting insulin before each meal and at bedtime. This is similar to what Frederick G. Banting used for his patients at University of Toronto[5]. We have noted essentially no change in renal function in a period of 26 mo. Although FBG or 2hPPG did not decrease between the two periods, dglucose was significantly reduced from baseline 63.5 ± 68.1 to 36.6 ± 65.6 mg/dL. We have noted that as dglucose increases above 50 mg/dL (2.7 mmol/L), serum creatinine increases in step wise fashion[6].

We have found in our previous study (unpublished) that although glucose levels did not decrease despite insulin therapy, renal function remained unchanged during the two periods of 14.2 mo. This indicates that insulin therapy is important for renal protection which

Table 1 A 78-year white male with established diabetes showed the following results in his first office visit

Glucose (mg/dL)		Scr (mg/dL)		eGFR (mL/min)	
F	2hPP	F	2hPP	F	2hPP
114 (6.3 mmol/L)	235 (13 mmol/L)	1.18	1.28	> 60	58
Dglucose (2hPPG-FBG) 121 mg/dL					

2hPP: 2-h postprandial; 2hPPG-FBG: 2-h postprandial blood glucose - fasting blood glucose; eGFR: Estimated glomerular filtration rate; Scr: Serum creatinine; F: Fasting.

may not be entirely dependent on tight glycemic control.

Hypertension control is achieved as always in author's patients by beta clockers, calcium channel blocker either alone or in combination, sympathetic inhibitor and in resistant cases, chlorthalidone. Angiotensin converting enzyme inhibitor (ACEI) or angiotensin receptor blocker (ARB) is excluded to reduce the risk of acute or chronic renal failure in diabetes[6,7].

We have previously reported that use of ACEI/ARB drug is associated with high risk of recurrent attack of acute renal failure or development of CKD in diabetes[7]. Other authors characterized acute kidney injury as a significant risk factor for CKD independent of other risk factors of progression in diabetes[8].

The pearl of wisdom of this editorial is the first step to establish the diagnosis of diabetes. The most sensitive test to establish the diagnosis is to order a post challenge glucose 2-h after a major meal. Blood glucose greater than 200 mg/dL, establishes the diagnosis of diabetes[9]. In order to monitor outcome measures in particular renal failure, it is important to order fasting and 2hPP basic metabolic panel which will provide glucose and renal function tests. The cornerstone of therapy of established diabetes is insulin therapy. Although evidence is tenuous for prevention of many of the complications of diabetes, author's studies confirm that insulin therapy is conducive to protection against renal failure and dialysis. Equally important in author's studies is to exclude use of renin-angiotensin inhibitors drugs to treat diabetes as a complimentary measure of protection for renal failure.

REFERENCES

1 **Reichard P**, Berglund B, Britz A, Cars I, Nilsson BY, Rosenqvist U. Intensified conventional insulin treatment retards the microvascular complications of insulin-dependent diabetes mellitus (IDDM): the Stockholm Diabetes Intervention Study (SDIS) after 5 years. *J Intern Med* 1991; **230**: 101-108 [PMID: 1865159 DOI: 10.1111/j.1365-2796.1991.tb00415.x]

2 The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. The Diabetes Control and Complications Trial Research Group. *N Engl J Med* 1993; **329**: 977-986 [PMID: 8366922 DOI: 10.1056/NEJM199309303291401]

3 **Patel A**, MacMahon S, Chalmers J, Neal B, Billot L, Woodward M, Marre M, Cooper M, Glasziou P, Grobbee D, Hamet P, Harrap S, Heller S, Liu L, Mancia G, Mogensen CE, Pan C, Poulter N, Rodgers A, Williams B, Bompoint S, de Galan BE, Joshi R, Travert F. Intensive blood glucose control and vascular outcomes in patients with type 2 diabetes. *N Engl J Med* 2008; **358**: 2560-2572 [PMID: 18539916 DOI: 10.1056/NEJMoa0802987]

4 **Mandal AK**, Hiebert LM, Khamis H. dGlucose is linked to renal function changes in diabetes. *Diabetes Res Clin Pract* 2011; **91**: 190-194 [PMID: 21146888 DOI: 10.1016/j.diabres.2010.11.013]

5 **Banting FG**. Diabetes and Insulin Nobel Lecture delivered in Stockholm, September 15, 1925. In history of Diabetes Mellitus Editors Savona-Ventura C, Mogasa CE. Elvevier, 2009

6 **Mandal AK**, Hiebert LM, Khamis, H. Control of dglucose is fundamental to renal preservation in diabetes. Presented in a poster session in American Society of Neprhrology, Philadelphia, 2015. Available from: URL: https://www.asn-online.org/

7 **Mandal AK**. Hibert LM: Renal protection in diabetes: It is affected by glucose control or inhibition of renin –angiotensin pathway. *Clin Nephrol* 2008; **69**: 189-178 [DOI: 10.5414/CNP69169]

8 **Thakar CV**, Christianson A, Himmelfarb J, Leonard AC. Acute kidney injury episodes and chronic kidney disease risk in diabetes mellitus. *Clin J Am Soc Nephrol* 2011; **6**: 2567-2572 [PMID: 21903988 DOI: 10.2215/CJN.01120211]

9 **Nosadini R**, Tonolo G. Relationship between blood glucose control, pathogenesis and progression of diabetic nephropathy. *J Am Soc Nephrol* 2004; **15** Suppl 1: S1-S5 [PMID: 14684663 DOI: 10.1097/01.ASN.0000093372.84929.BA]

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REVIEW

Diabetes and cardiovascular disease: Epidemiology, biological mechanisms, treatment recommendations and future research

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Abstract

The incidence of diabetes mellitus (DM) continues to rise and has quickly become one of the most prevalent and costly chronic diseases worldwide. A close link exists between DM and cardiovascular disease (CVD), which is the most prevalent cause of morbidity and mortality in diabetic patients. Cardiovascular (CV) risk factors such as obesity, hypertension and dyslipidemia are common in patients with DM, placing them at increased risk for cardiac events. In addition, many studies have found biological mechanisms associated with DM that independently increase the risk of CVD in diabetic patients. Therefore, targeting CV risk factors in patients with DM is critical to minimize the long-term CV complications of the disease. This paper summarizes the relationship between diabetes and CVD, examines possible mechanisms of disease progression, discusses current treatment recommendations, and outlines future research directions.

Key words: Diabetes mellitus; Cardiovascular disease; Mechanism; Treatment

Core tip: The link between diabetes and cardiovascular disease (CVD) is summarized and discussed in detail with a focus on growing prevalence, mechanisms of disease progression and current treatment of CVD in diabetic patients. Directions of future research are also examined.

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and future research. *World J Diabetes* 2015; 6(13): 1246-1258 Available from: URL: http://www.wjgnet.com/1948-9358/full/v6/i13/1246.htm DOI: http://dx.doi.org/10.4239/wjd.v6.i13.1246

INTRODUCTION

The incidence of diabetes mellitus (DM) is increasing substantially worldwide. Over the past three decades, the global burden of DM has swelled from 30 million in 1985 to 382 million in 2014, with current trends indicating that these rates will only continue to rise[1]. The latest estimates by the international diabetes federation project that 592 million (1 in 10 persons) worldwide will have DM by 2035[2]. While the rates of both type 1 DM (T1DM) and T2DM are growing, T2DM has a disproportionately greater contribution to the rising prevalence of DM globally compared to T1DM[1]. One consequence of the growing rates of DM is a considerable economic burden both for the patient and the healthcare system. In the United States, the total cost of DM averages $2108/patient per year, which is nearly twice that of non-diabetic patients[3]. The economic burden associated with DM is substantial both in terms of the direct costs of medical care as well as indirect costs of diminished productivity tied to diabetes related morbidity and mortality[4]. The direct costs of DM are primarily attributed to both macrovascular and microvascular complications such as coronary artery disease, myocardial infarction, hypertension, peripheral vascular disease, retinopathy, end-stage renal disease and neuropathy[3,4].

A close link exists between DM and cardiovascular disease (CVD). CVD is the most prevalent cause of mortality and morbidity in diabetic populations[5]. CVD death rates in the United States are 1.7 times higher among adults (> 18 years) with DM than those without diagnosed DM, largely due to an increased risk of stroke and myocardial infarction (MI)[6]. This increased risk of CVD mortality in diabetic patients is found in both men and women. The relative risk for CVD morbidity and mortality in adults with diabetes ranges from 1 to 3 in men and from 2 to 5 in women compared to those those without DM[7].

Proper control and treatment of DM is critical as both the prevalence and economic burden of the disease continue to mount. As CVD is the most prevalent cause of mortality and morbidity in patients with DM, a primary goal of diabetes treatment should be to improve the cardiovascular (CV) risk of diabetic patients. However, one challenge associated with treating DM and reducing CV events is the complex and multifaceted nature of the relationship linking DM to CVD. CV risk factors including obesity, hypertension and dyslipidemia are common in patients with DM, particularly those with T2DM. In addition, studies have reported that several factors including increased oxidative stress, increased coagulability, endothelial dysfunction and autonomic neuropathy are often present in patients with DM and may directly contribute to the development of CVD[5]. Collectively, the high rates of CV risk factors and direct biological effects of diabetes on the CV system place diabetic patients at increased risk of developing CVD, and contribute to the increased prevalence of MI, revascularization, stroke and CHF[5,8]. Due to the complexity and numerous mechanisms linking DM to CVD, it is crucial to focus treatment to what will have the greatest clinical impact on improving CV outcomes. This paper examines the mechanisms linking DM to CVD as well as current treatment recommendations and future research in diabetes management.

CV RISK FACTORS AND CVD

Obesity

Obesity is common in patients with DM, particularly T2DM, and is associated with an increased risk of CVD. One possible mechanism linking DM and obesity with subsequent CVD is low-grade inflammation[9]. DM and insulin resistance are associated with the overexpression of many cytokines by adipose tissue including tumor necrosis factor-α, interleukin (IL)-1, IL-6, leptin, resistin MCP-1, PAI-1, fibrinogen and angiotensin[10]. The overexpression of these cytokines contributes to increased inflammation and lipid accumulation, which have a deleterious effect on blood vessels and can lead to the development of endothelial dysfunction, MI and cardiomyopathy (CMP)[5,11-14]. Diabetic patients also have increased amounts of C-reactive protein (CRP), which may contribute to endothelial dysfunction. Many studies have demonstrated that CRP impairs endothelial production of nitric oxide (NO) and prostacyclin, which are vital to vessel compliance. CRP has also been shown to increase the uptake of oxidized low-density lipoprotein (LDL) in coronary vasculature walls, which can contribute to endothelial dysfunction as well as the development of atherosclerotic plaques[14]. Patients with DM also have decreased adiponectin production, which may result in diminished endothelial function[10]. Adiponectin helps limit endothelial dysfunction by increasing NO production and reducing the expression of adhesion molecules. Adiponectin is also protective in the atherosclerotic process by inhibiting LDL oxidation[15]. This increase in atherosclerotic plaque can place diabetic patients at a heightened risk of MI. In particular, increased levels in the inflammatory cytokine IL-1, as seen in patients with DM, can contribute to the destabilization of atheromatous plaques and subsequent MI[11]. Insulin resistance is also associated with an elevation of plasma free fatty acids, leading to increases in muscular triglycerides stores, hepatic glucose production, and increased insulin production in patients with T2DM[16]. Insulin resistance has also been linked to CMP in diabetics *via* cardiomyocyte hypertrophy and contractile dysfunction[16,17].

Hypertension

Hypertension is very common among patients with

T1DM and T2DM, with prevalence rates of 30% and 60%, respectively[5]. Hypertension among diabetic patients is closely tied to the development of diabetic nephropathy (DN)[18]. With DN, renal cells are stimulated by hyperglycemia, leading to the production of humoral mediators, cytokines, and growth factors. The production of these factors is often responsible for structural alterations seen in the glomeruli of diabetic patients including hyaline arteriolosclerosis (primarily of the efferent arteriole), increased collagen deposition of the extracellular matrix, and increased permeability of the glomerular basement membrane[19]. These structural changes increase filtration pressure and often lead to microalbuminemia with a compensatory activation of the renin-angiotensin system (RAAS). Chronic activation of the RAAS often progresses to hypertension, placing added stress on the glomeruli and causing additional damage to the nephrons of diabetic patients. If left untreated, DN can progress to a nephrotic syndrome, characterized by proteinuria, a hypercoagulable state (due to loss of ATIII) and hyperlipidemia, which may contribute to the increased risk of CVD seen in diabetic patients with renal dysfunction[20,21].

Dyslipidemia

Diabetic patients are at increased risk of developing dyslipidemia[22]. One mechanism underlying this connection is increased free fatty-acid release present in insulin-resistant fat cells. High levels of free-fatty acids promote triglyceride production, which in turn stimulates the secretion of apolipoprotein B (ApoB) and very LDL (VLDL) cholesterol. High levels of ApoB and VLDL have both been tied to increased risk of CVD[23-26]. In addition to high ApoB and VLDL, hyperinsulinemia is associated with low high-density lipoprotein (HDL) cholesterol levels[27]. Hyperglycemia may also negatively impact lipoproteins (particularly LDL and VLDL) through increased glycosylation and oxidation, decreasing vascular compliance and facilitating the development of aggressive atherosclerosis[28]. High circulating FFA's and triglycerides, increased stimulation of ApoB and VLDL cholesterol, decreased HDL levels and lipoprotein modification have all been appreciated in patients with DM and likely contributes to the high prevalence of CVD in diabetic patients.

Diabetic cardiomyopathy

DM appears to contribute directly to the development of CMP, rather than solely *via* coronary atherosclerosis and hypertension[29]. This diabetic CMP has been described in many noninvasive studies and includes changes that occur in LV structure and cardiac function of diabetics. Specifically, diabetics tend to have greater cardiac mass, particularly LV mass, than those without DM[30,31]. This may be related to an increased adipocyte release of cytokines such as leptin and resistin which have hypertrophic effects on cardiomyocytes[12,13]. One study looking at a multi-ethnic population found that the likelihood of having LV mass that exceeds the 75th percentile is greater in patients with T2DM, even after adjusting for covariates[32]. Patients with DM also tend to have a slightly diminished diastolic function compared to nondiabetics[33-35]. One possible mechanism could be that increased triglyceride synthesis in patients with DM leads to increased myocardial triglyceride content[36]. Increased cardiac triglyceride accumulation is associated with lipotoxicity and altered calcium hemostasis in myocardium, both of which negatively impact diastolic function[37-39]. This could help explain the finding that 40%-75% of individuals with DM and no signs of overt coronary artery disease (CAD) suffer from diastolic dysfunction[34,35]. Subtle abnormalities in systolic function have also been observed in patients with DM using tissue Doppler imaging and Doppler strain analysis of peak systolic velocity[40-44]. This systolic dysfunction may be related to impaired myocardial sympathetic innervation and impaired contractile reserve[45]. In addition, interstitial fibrosis with increased collagen deposition has been observed in patients with DM and may negatively contribute to the diminished cardiac function seen in diabetics[46]. It is likely that many of the mechanisms that contribute to reductions in systolic and diastolic function seen in diabetic patients also place them at an increased risk of heart failure (HF)[47,48]. The prevalence of HF, particularly heart failure and preserved ejection fraction, is higher in diabetic patients (16%-31%) than the general population (4%-6%)[49]. While some of the difference may be accounted for by traditional CV risk factors, DM may independently alter cardiac structure and function by promoting hypertrophy and fibrosis[50].

Cardiovascular autonomic neuropathy

Cardiovascular autonomic neuropathy (CAN) is common among patients with DM and is correlated with an increased 5-year mortality rate from CVD[51]. The clinical manifestations of CAN are resting tachycardia, postural hypotension, exercise intolerance, abnormal coronary vasomotor regulation, increased QT interval, and perioperative instability. Collectively, the clinical manifestations of CAN are related to an increased risk of renal disease, stroke, CVD and sudden death[52]. The development and progression of CAN is likely related to dysregulation of the autonomic nervous system (ANS) with increased sympathetic activity and elevated inflammatory markers. As the ANS is responsible for maintaining the activity of the sinus node, end diastolic volume, end systolic volume and systemic vascular resistance, ANS dysfunction can lead to arterial stiffness, left ventricular hypertrophy and ventricular diastolic dysfunction[53]. Incidence of CAN increases with age and inadequate glycemic control, which places patients with DM at higher risk of developing both CAN and CVD[54].

Myocardial infarction and DM

Diabetes is a major risk factor for the development of CAD with a higher incidence of MI in patients with DM than those without[55,56]. In addition, following a MI, diabetic patients have higher rates of morbidity,

mortality and re-infarction than non-diabetics, with one-year mortality rates of nearly 50%[57]. Although the exact pathophysiology of CAD progression in patients with DM has not yet been determined, the most recent studies postulate that the underlying atherosclerotic process is similar between those with and without DM. It is thought that the higher incidence of myocardial infarction in patients with DM is attributable to increased coagulability[58]. Many studies have found that diabetics have increased expression of glycoprotein ⅡB/ⅢA receptors and vWF, which are responsible for platelet activation[59,60]. Patients with DM also have increased plasminogen activator inhibitor type 1 which could decrease fibrinolysis, increase thrombus formation and accelerate plaque formation[61]. Finally, diabetic patients also tend to have decreased circulating anti-coagulants such as protein c and antithrombin Ⅲ due in a large part to the proteinuria present with DN[62]. Collectively, these factors place patients with DM in a prothrombotic and procoagulant state, which may account for the higher rates of MI seen in diabetic patients.

Silent myocardial ischemia may also contribute to the higher rates of MI seen in diabetic patients. Ischemia and subsequent angina often serves as an early warning system to patients developing obstructive CAD[63]. However, those with silent ischemia are often asymptomatic and diagnosed later into the progression of CAD, which is associated with higher rates of MI-related mortality and morbidity[64]. Silent ischemia is far more prevalent in patients with DM (10%-20%) than those without DM (1%-4%). This disparity may be responsible for the observation seen in some angiographic studies where CAD was usually more advanced at the time of diagnosis in diabetic patients[65,66]. Diabetic neuropathy is one factor that may explain the increased incidence of silent ischemia in patients with DM[67,68].

TREATMENT

As CVD is the most prevalent cause of mortality and morbidity in patients with DM, effective treatment is critical to lower the subsequent risk of CV events, particularly MI, CAD, stroke and CHF in diabetics. Suboptimal glycemic control, obesity, hypertension, dyslipidemia and autonomic dysfunction are common CV risk factors among diabetic patients, placing them at heightened risk of CV complications. Therapy that is targeted to modify these risk factors can improve CV outcomes, but this can be a challenging to achieve. The guidelines pertaining to these risk factors typically vary from the guidelines for non-diabetic patients and the recommendations often change or differ depending on what organization publishes them. In addition, the research on how these different risk factors affect the CV risk profile of diabetics can be unclear, and at times, contradictory. The purpose of this section is to provide the most recent guidelines for the treatment of glycemic control, hypertension, dyslipidemia and autonomic dysfunction in patients with DM, and also describe the research that pertains to each of these topics.

GLYCEMIC CONTROL

As many studies have linked poor glycemic control to worse CV outcomes, current treatment recommendations for patients with DM place a heavy emphasis on closely monitoring and controlling glycemic levels in an effort to improve cardiac outcomes. The exact glycemic level that should be targeted for diabetics, however, is controversial and varies depending on which organization is making the guideline. For example, the current recommendation by the American Association of Clinical Endocrinologists Guidelines has a goal hemoglobin A1c (HbA1c) of less than or equal to 6.5%, and encourages providers to treat patients with an A1c value greater than 6.5% with a combination of lifestyle modification, weight loss and pharmacological agents[69]. The ACC/AHA have a slightly more relaxed A1c goal of less than 7% for non-pregnant patients with T1DM or T2DM in order to reduce the risk of microvascular or macrovascular complications. In addition, ACC/AHA also qualifies their recommendation by including a recommendation that an A1c goal of greater than 7 may be appropriate for patients with a history of severe hypoglycemia, limited life expectancy, advanced microvascular or macrovascular complications, extensive comorbidities, or for those with long-standing diabetes. The recommendation also states that an A1c goal lower than the general goal of less than 7.0% may be beneficial for certain diabetic patient populations including those with a short duration of diabetes, long life expectancy, and no CVD[70]. The VA/DoD guidelines use a more individualized algorithm for determining an appropriate A1c goal for diabetic patients. This guideline range from a target A1c of < 7 to < 9 depending on the patient's current health status, comorbid conditions, life expectancy, risk of hypoglycemia and duration of diabetes status[71].

CV OUTCOMES

There have been many studies that have investigated the effect of intensive treatment of hyperglycemia on CV outcomes in patients with diabetes. The UKPDS trial was one of the first multi-center, randomized control trials to investigate the effect of intensive glycemic control in patients with recently diagnosed T2DM. Patients were either randomized to "conventional" or "intensive" glycemia-lowering therapy and were followed for 10 years. The intensive glycemic group reduced HbA1c by 11% over 10 years (median 7.0%) as compared to the group treated with conventional therapy who did not have a significant change in their HbA1c (median 7.9%). The primary effect seen in the group with tighter glycemic control was a 12% reduction in all diabetes-related endpoints and a 25% reduction in microvascular disease (primarily through decreased retinopathy). In addition, the intensive therapy group trended towards a

decrease in macrovascular disease although it was not statistically significant[72].

Another large study that investigated the effect of tight glycemic control in patients with T2DM was the VADT trial. The population for this study consisted primarily of older (mean age 60.4 years) adult men with poorly controlled T2DM (average HbA1c of 9.4%) and an average duration of disease of 11.5 years. The subjects were randomized to either "intensive" or "conventional" glycemia-lowering therapy and were followed for 5.6 years. The group with the tighter glycemic control did have a significantly greater decrease in A1c levels over the course of the study (6.9% *vs* 8.4%), but there was no significant decrease in MI or all cause mortality in the "intensive" therapy group as compared to the "conventional" therapy group[73].

The ADVANCE trial placed a focus on the vascular effects of intensive glycemic therapy in adults with T2DM. This large multi-center randomized control trial recruited T2DM patients with a history of major macrovascular or microvascular disease from 215 collaborating centers in 20 countries. Subjects were randomized to either an "intensive" or "standard" glycemia-lowering strategy and followed for 5 years. The intensive glycemic therapy group was treated to an HbA1c of less than or equal to 6.5%. The group randomized to the tighter glycemic control did have a significantly greater reduction in HbA1c (6.5% *vs* 7.3%) and experienced a 23% reduction in microvascular events (primarily nephropathy). However, there was no difference between the groups in MI or all cause mortality and the group with 'intensive' therapy had increased rates of severe hypoglycemia hospitalization[74].

The ACCORD trial was conducted concurrently to the ADVANCE trial and focused primarily on whether intensive glycemic control reduced to risk of CV events. This multi-center randomized control trial investigated if very tight glycemic control (less than or equal to an HbA1c of 6%) had lower rates of nonfatal MI, nonfatal stroke and CV death than standard glycemic control (HbA1c of 7%-7.9%) in older adults. The subjects were followed for an average of 3.4 years and the group with the tighter glycemic control did achieve a significantly lower HbA1c than those with standard treatment (7.3% *vs* 6.5%). The intensive glycemic control group had slightly lower rates of nonfatal MI, but after 3.7 years the trial was stopped early because the intensive treatment group had increased rates of all-cause and CV mortality. The group with tight glycemic control also had increased weight gain, and risk of hypoglycemia as seen in the ADVANCE trial[75].

DCCT and the long-term follow-up trial EDIC investigated how strict glycemic control with intensive therapy effected CV outcomes in patients with T1DM. These trials randomized young (ages 13-39 years) patients with T1DM to either "intensive" or "conventional" glycemic therapy with an HbA1c goal of 7% in the group for those in the "intensive" treatment group. The primary finding of the DCCT trial was that after 10 years of follow-up, the group with strict glycemic control had a 70% decrease in the number of microvascular complications, particularly retinopathy. In addition, the long-term follow-up study, EDIC, found a 42% reduction in CV events in the group with intensive glycemic treatment as compared to the conventional glycemic therapy[18,76].

While it does appear that a link exists between glycemic control and CV outcomes in diabetic patients, the findings thus far on the effect of tight glycemic control on CVD are conflicting. Current studies fail to show that intensive glycemic control (HbA1c $\leqslant$ 6.5%) has a significant CV benefit compared to standard glycemic control targets (HbA1c of 7%-7.9%) in patients with T2DM. While there may be a small reduction in the number of microvascular events in T2D patients with the tighter glycemic control, there does not seem to be a sizeable benefit in the rates of all-cause and CV-specific mortality. Furthermore, very tight glycemic control (HbA1c $\leqslant$ 6%), as seen in the ACCORD trial, may place patients at additional risk of hypoglycemia, weight gain and all cause mortality[75]. In patients with T1DM, tighter glycemic control does appear to be beneficial. The DCCT and EDIC trials do suggest that intensive glycemic therapy (goal HbA1c $\geqslant$ 7%) can help reduce rates of microvascular and macrovascular disease in T1D[18,76].

One potential interpretation of the studies thus far is that the concurrent CV risk factors present in diabetics may overwhelm any benefit that intensive treatment of hyperglycemia can provide in reducing risk. Thus, diabetic patients who achieve tighter glycemic control earlier during their disease course and prior to the development of other CV risk factors may see the greatest benefit from more intensive therapy in terms of CV outcomes. For this reason, many of the new recommendations look to tailor A1c goals to the individual patient as opposed to a single A1c cutoff for all diabetic patients. The ACC/AHA and VA/DoD, for example, adjust their glycemic goals based on factors such as age, years with the disease and CV risk[70,71]. While further studies are needed to determine what the best glycemic treatment goal is for these different patient populations, adjusting the target A1c depending on the individual's current level of CVD risk may provide benefit to diabetic patients.

Obesity

Obesity is a common comorbidity of DM, particularly T2DM, and is linked with higher rates of CV morbidity and mortality. Thus, current treatment recommendations encourage weight loss in overweight and obese patients with DM to improve their CV risk profile and decrease the risk of CVD. The recommendation is for 5% weight loss over 4 years in diabetic patients that are overweight or obese. A "moderate" amount of evidence suggests that 5% weight loss by lifestyle intervention is associated with an increase in HDL-c, a reduction in triglycerides and a decrease in newly prescribed lipid lowering medications in diabetic patients. In addition, there is a "high" level of evidence suggesting that orlistat results in

2-3 kg of weight loss in overweight and obese diabetic patients at 1 and 2 years, and is associated with greater reductions in fasting blood glucose and HbA1c. These recommendations were graded as high, moderate, or low on the basis of scientific methodology, scientific strength, and consistency of results[77].

As obesity is a major risk factor both for CVD and T2DM, many studies have investigated the efficacy of weight loss in reducing the development and severity of DM. Some studies have focused on body weight reduction in pre-diabetic patients in order to decrease the incidence of subsequent DM. Of note, the diabetes prevention program (DPP) and finnish diabetes prevention studies evaluated the effect of behavior modification on weight loss and consequent risk of developing diabetes in pre-diabetic adults. Both studies yielded similar results in that those randomized to the lifestyle intervention group had significantly greater weight loss and reduced risk of developing diabetes as compared to the control group[78,79]. Other studies have looked at methods for attaining weight loss and improving the CV risk profile of patients who are already diabetic. A variety of techniques including intensive lifestyle intervention, weight loss medications and bariatric surgery were effective in achieving weight loss and improving the CV risk profile of diabetic patients through improved glycemic control, blood pressure and cholesterol levels[80-82].

Although many studies have shown that weight loss can be achieved in diabetic patients, there is mixed evidence as to whether weight loss in these patients actually reduces subsequent CV morbidity and mortality. Thus far, there has been mixed evidence if modest weight loss in patients with DM does improve their CV risk. While the SCOUT trial found that modest weight loss could improve 5-year CV mortality rates among diabetic patients, the Look AHEAD trial did not find that weight loss had any effect on CV mortality, MI, stroke, or angina hospitalization after 9.6 years of follow-up[83,84].

The current recommendation for overweight and obese patients with DM is a goal weight loss of 5%[77]. Studies thus far have demonstrated that this goal is attainable both in pre-diabetic and diabetic patients through a variety of techniques including intensive behavioral modification therapy, pharmacological agents and bariatric surgery. In addition, all of these methods of weight loss appear to either decrease the rates of incident DM in pre-diabetic patients, or improve the CV risk profile of diabetic patients[78-82]. However, it is unclear whether modest weight loss in diabetic patients translates to a decrease in CVD[83,84].

It is possible that the CV risk profile is too high in older adults with DM for modest weight loss to make a significant improvement in CV outcomes. It might be more advantageous to focus obesity treatment efforts on pre-diabetics before they develop DM. Programs such as the DPP have demonstrated that weight loss can decrease the rate of incident diabetes, but further research is needed to determine if modest weight loss in pre-diabetic patients results in improved CV morbidity and mortality[78]. It is also possible that while modest weight loss does seem to improve the CV risk profile of patients with DM, even greater weight loss is necessary to see more definitive improvements in the rates of CV events. Further investigation into the effects of weight loss greater than 5% on CVD in diabetic patients may help identify the existence of a dose effect with weight loss and CV health.

Hypertension

Since hypertension is a common comorbidity of patients with DM and a major risk factor for CVD, the current treatment recommendations strongly encourage providers to lower BP in hypertensive diabetics. There are many studies that have investigated the effect of lowering blood pressure in patients with diabetes on CV outcomes. The UKPDS 38 trial examined the effect of tight control of blood pressure control (< 150/85) compared to less tight control (< 180/105) on macrovascular and microvascular complications in patients with T2DM. After 9 years follow-up, mean blood pressure was significantly lower in the tightly controlled BP group (144/82 mmHg) compared to the patients in the less tightly controlled group (154/87 mmHg). In addition, the group with tighter BP control had a 34% reduction in macrovascular disease risk (myocardial infarction, sudden death, stroke, and peripheral vascular disease) and a 37% reduction in risk of microvascular disease (retinopathy requiring photocoagulation, vitreous haemorrhage, and fatal or non-fatal renal failure) compared with the less tightly controlled BP group[85].

While many studies have shown that lowering BP in diabetics does improve CV outcomes, the ACCORD-BP trial investigated the effect of intensive BP control (systolic BP < 120 mmHg) compared to standard BP control (systolic BP < 140 mmHg) on the risk of fatal or nonfatal major CV events in patients with T2DM. After 4.7 years of follow-up, the group with intensive BP control did not have a reduction in fatal and nonfatal major CV events as compared to the standard BP control group (1.87% *vs* 2.09% per year). In addition, the intensive BP group had increased adverse events including hypotension, syncope, bradycardia or arrhythmia, hyperkalemia, angioedema and renal failure[86].

Given the results of these trials, recent treatment recommendations indicate that, pharmacologic treatment should be initiated at a SBP of > 140 mmHg or a DBP of > 90 mmHg for diabetic adults between 18 and 60 years of age. For patients older than 60, the threshold to initiate treatment is a SBP of < 150 mmHg or a DBP of < 90 mmHg. The recommendation on the type of pharmacological therapy that should be used varies in the general nonblack *vs* black population. For nonblack patients with DM and hypertension, initial treatment should include a thiazide-type diuretic, calcium channel blocker (CCB), angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker

(ARB). For black patients with DM and hypertension, the initial treatment should include a thiazide-type diuretic or a CCB. In addition, hypertensive patients with DM and CKD should be treated with an ACE inhibitor or an ARB to improve kidney outcomes[87]. While different antihypertensive agents used to treat hypertension have varying metabolic effects, many studies, including the ALLHAT trail, found no significant difference in the risk of coronary heart disease, nonfatal myocardial infarction, total mortality, or other clinical complications attributable to the initial antihypertensive drug therapy used to treat diabetic patients[88,89]. This would suggest that metabolic differences between the various antihypertensive agents do not play a major role in the subsequent development of CVD in patients with DM. It should be noted that these recommendations have been controversial and several authors have argued that the guideline is too relaxed in the treatment of certain at-risk groups including African Americans, women and the elderly based on previous studies evaluating blood pressure control and subsequent CVD in these populations[90]. There is likely a therapeutic BP range that provides diabetic patients with a lower CV risk but also protects them from adverse events associated with hypotension. Whether the new guidelines, particularly with the increased systolic BP threshold in adults over 60 years, match this therapeutic BP range is yet to be determined. There is also little evidence as to what the proper treatment range should be for different age groups. In addition, hypertension in different racial subgroups may have different effects on CV health. Further research is needed to investigate the ideal BP range for adults of different age groups as well as different racial groups.

Dyslipidemia

Dyslipidemia is both common in patients with DM and associated with increased risk of CVD[91,92]. Health providers are encouraged to identify and aggressively treat patients with dyslipidemia to help diminish their risk of subsequent CV events. The current recommendation for treating dyslipidemia in diabetic patients varies by age and is in line with recognition that treatment with fixed-dose statins, rather to specific LDL target levels, is the validated approach from clinical trials. Accordingly, diabetic patients who are under the age of 40 are recommended to take a high-intensity statin if they have clinical evidence of atherosclerotic CVD or a LDL-c greater than 189 mg/dL. All diabetic patients over the age of 40 are encouraged to begin statin therapy. Patients over 40 with an estimated 10-year ASCVD risk greater than 7.5% are treated with a high-intensity statin, and patients with a 10-year ASCVD risk less than 7.5% are treated with a moderate-intensity statin[93].

There have been many studies conducted to determine the effect of treating dyslipidemia in diabetic patients as a means to lower CV risk. The CARDS study was the first multicenter randomized controlled trial to evaluate statin therapy prospectively in patients with T2DM. Adult patients with T2DM were randomized to either receive a placebo or 10 mg/d of atorvastatin. The median follow-up time was 3.9 years and the group treated with atorvastatin had an average 26% reduction in total cholesterol and a 40% reduction in LDL-c. In addition, the statin therapy group had a 37% reduction in CV events, a 27% reduction in all-cause mortality and a 48% reduction in stroke as compared to the group treated with the placebo. The CARDS trial was stopped early to due the significant benefit demonstrated with statin therapy[94].

After the CARDS trial found that statin therapy provided a significant CV benefit to diabetic patients, the TNT trial examined the effect of high-dose statins on CAD mortality, non-fatal MI, and fatal or nonfatal stroke in diabetic patients with T2DM. Adult patients with T2DM were randomized to receive either a high dose (80 mg/d) or low dose (10 mg/d) statin and followed on average for 4.9 years. The high dose stain group achieved a greater reduction in LDL-c (77 mg/dL *vs* 101 mg/dL) and had a greater reduction in combined CAD mortality, non-fatal MI, or fatal or nonfatal stroke (8.7% *vs* 10.9%) compared to the lower dose group. However, it was noted that the higher dose group did have a higher rate of adverse events (myalgia, persistent elevation in alanine aminotransferase, aspartate aminotransferase, or rhabdomyolysis)[95].

As many studies had demonstrated that statins, particularly high-dose statins, had CV benefit in diabetic patients, the 4D study examined the effect of statins in diabetic patients receiving hemodialysis. In the 4D trial, diabetic patients receiving hemodialysis were randomly assigned either 20 mg of atorvastatin per day or a placebo. The purpose of the study was to determine if a low-dose statin in diabetic patients with end stage renal disease lowered the rates of death from cardiac causes, nonfatal myocardial infarction, and stroke as compared to the placebo group. The group randomized to the statin therapy did have a significant reduction in their LDL-c compared to the placebo group (-42.0% *vs* -1.3%), but there was no significant difference between the groups in CV outcomes after 3.96 years of follow-up. In addition, there were significantly more cases of fatal stroke in the statin therapy group than those treated with a placebo[96].

While the previous studies had focused on reducing cholesterol in diabetic patients using statin therapy, other research groups have investigated the effect of non-statin lipid-lowering therapies on CVD in diabetic patients. For example, the FIELD trial evaluated if lowering cholesterol *via* fenofibrate therapy could improve CV outcomes in patients with DM. In the FIELD trial, diabetic patients (mean age 62 years; 63% men) were randomized to either receive a fenofibrate (200 mg/d) or a placebo and then assessed for subsequent rates of fatal coronary heart disease (CHD) or nonfatal MIs. While the group randomized to the fenofibrate therapy did reduce their cholesterol compared to the placebo group at 4 mo (total cholesterol, LDL-cholesterol, and triglycerides by 11%, 12%, and 29%, respectively),

the differences decreased between the groups as the trial continued due in a large part to patients starting additional cholesterol lowering therapies outside of the study. After a median of 5 years, the group randomized to the fenofibrate group had a combined 11% reduction in fatal CHD or nonfatal MIs, but this difference was non-significant. The fenofibrate group did however have a statistically significant reduction (24%) in nonfatal MI's compared to the placebo group[97]. In addition, since HDL has been identified in many large prospective studies to be associated with improved CV health, some research groups have investigated whether raising HDL through pharmaceutical agents reduces the risk of CV events. The HATS trial was the first to investigate the effect of increasing HDL with Niacin therapy and generated promising results on improving CV outcomes in adult patients (16% with DM). After 38 mo of follow-up, the group randomized to the niacin therapy did have a significant increase in HDL and patients with T2DM had a 13% decrease in absolute risk of CV disease[98]. Recently however, the AIM-HIGH trial found no significant clinical benefit in adding Niacin therapy to patients with atherosclerotic CVD as compared to a placebo. The trial was stopped after 3 years due to lack of efficacy; the group randomized to the niacin therapy (34% with DM) did not have a significant reduction in composite coronary heart disease, nonfatal myocardial infarction, ischemic stroke, hospitalization for an acute coronary syndrome, or symptom-driven coronary or cerebral revascularization (16.4% *vs* 16.2%) despite significant improvements in HDL (25% *vs* 11.8%). These findings were similar between diabetics and nondiabetics[99].

Dyslipidemia is prevalent among diabetic patients and a major risk factor for CVD[91,92]. Current treatment recommendations encourage providers to lower lipid levels in diabetic patients, primarily through the use of statins, with a dose dependent on the patient's level of risk. Some trials have also investigated if additional CV benefit can be achieved in patients with DM by combining a statin with other lipid-lowering therapies. For example, the IMPROVE-IT trial found that the combination of ezetimibe (a cholesterol absorption inhibitor) with simvastatin was superior to simvastatin alone in reducing CV events for diabetic patients with acute coronary syndrome[100]. The evidence thus far suggests that statin therapy in patients with DM is advantageous for CV health and that higher doses, as well as combined lipid-lowering therapy, can provide additional CV protection[93]. While some meta-analyses have suggested that statin therapy could be associated with increased incidence of DM, the absolute benefit of the therapy in diabetic patients largely outweighs the risk[101]. Other lipid lowering agents, such as fenofibrates, have not demonstrated the same level of efficacy and reductions in CV events as statins[97]. Pharmacological agents that raise HDL also appear to provide minimal, if any, CV benefit[98,99]. Further studies are necessary to better understand the role of HDL in CV health.

CAN

CAN is a common complication of diabetes and places patients with DM at increased risk of CV related morbidity and mortality. The autonomic dysfunction commonly found in diabetic patients is associated with a high risk of cardiac arrhythmias and sudden death, as well as other serious CV sequelae including silent myocardial ischemia, diabetic cardiomyopathy, stroke, and both intraoperative and perioperative CV instability. Some of the most common clinical manifestations of CAN include heart rate variability (variability in the instantaneous beat-to-beat intervals), resting tachycardia, exercise intolerance, orthostatic hypotension and abnormal blood pressure regulation[102].

Early treatment of autonomic dysfunction can slow the pathogenesis and complications of CAN[102]. Some studies have shown that tight glycemic control may play an important role in reducing the incidence of CAN in patients with DM. For example, the DCCT demonstrated that patients with better glycemic control, as measured by Hba1c, had significantly lower risk of developing autonomic dysfunction according to a CAN index[103]. While the effect of glycemic control on CAN in patients with T2DM have been less conclusive, some trials, including the Steno-2 study found that improving glucose control and other CV risk factors reduced the prevalence of CAN in T2DM patients[104]. Lifestyle interventions that focus on improving exercise endurance and promote weight loss have also improved autonomic dysfunction. Pharmacological therapy including ACE inhibitors, angiotensin receptor blockers and aldose reductase inhibitors also appear to help slow the progression of CAN[54]. In addition, IGF-1, ACE inhibitors and beta-blockers appear to be beneficial in the treatment of diabetic cardiomyopathy by slowing ventricular hypertrophy and normalizing the calcium homeostasis in diabetic cardiomyocytes[105-109]. Further studies are necessary, however, to validate what the best pharmacological treatment is for diabetic patients with CAN.

FUTURE DIRECTIONS IN THE TREATMENT OF DM

While there have been many trials that have helped further the understanding of DM as it relates to CVD, further research is required to better identify and quantify CV risk in patients with DM. Determining how glycemic control relates to CVD is one another area where additional research is needed. There is some evidence that improved glycemic control does in fact improve CV outcomes patients with DM[72,73]. One study even found that HbA1c in non-diabetic patients is an independent predictor of coronary artery disease and its severity which would suggest that glycemic control is critical to managing CV health in all patient populations[110]. While this observational trial suggests an independent association may exist between glycemic

levels and CVD, large randomized control trials such as ADVANCE and ACCORD have shown that the effect of tight glycemic control on subsequent CVD is modest and largely attributable to coexistent traditional risk factors[73-75,110].

One possible explanation for the conflicting results surrounding the relationship between glycemic control and CVD is due to poor measurement tools. For example, fasting plasma glucose (FPG) is often used as a measure of glycemia, but studies have found a day-to-day within-person variance of 12%-15% in FPG levels of diabetic patients[111]. While the day-to-day within-person variance for HbA1c is far better (< 2%), there is evidence that HbA1c does not accurately reflect glycemic control due to biological variations and differences in RBC survival among patients[111-113]. If glycemic control does matter, properly measuring glycemia and correlating it to CV risk is essential in order to set clinically meaningful goals for patients with DM.

The duration and onset of improved glycemic control may also contribute to the progression and severity of CVD. The UKPDS demonstrated that tight glycemic control was associated with reductions in CV outcomes in middle-aged adults (median 54 years) who were recently diagnosed with DM[72]. Conversely, the ADVANCE and ACCORD trials reported that tight glycemic control may not provide any reduction in subsequent CVD and may actually be harmful in patients that were slightly older and with a longer duration of diabetes[74,75]. This might reveal that treating hyperglycemia aggressively in high-risk patients with longer-standing DM is too late to have a clinically significant impact, and that earlier, aggressive treatment among patients shortly after DM diagnosis may be more beneficial. More studies are needed to better understand the relationship between glycemic control and the development of CVD and determine if the onset and duration of treatment matters in the reduction of CV events in patients with DM.

Further research is also necessary to determine what the best treatment is to decrease the risk and severity of cardiomyopathy and CAN in patients with DM. Many studies have demonstrated that autonomic dysfunction and diabetic cardiomyopathy are disease processes that are not only common in patients with DM, but also place them at increased risk of subsequent CV complications[102]. Lifestyle modification, tighter glycemic control and pharmacological agents appear to provide some benefit in slowing the progression of CAN and diabetic cardiomyopathy[54,102-109]. However, few studies have investigated what specific therapy is most effective in treating these conditions, as well as what might be done to prevent the development of these disease processes altogether.

Additional research is also needed to better understand how traditional CV risk factors including dyslipidemia, obesity and blood pressure should be monitored and managed in diabetic patients. For example, combination therapy may be the best way to treat dyslipidemia, contrary to the current recommendation that focuses primarily on statin mono-therapy. More studies like IMPROVE-IT could help determine what therapy is most effective to manage dyslipidemia in diabetic patients[100]. In addition, the role of HDL on CV health is complicated, and further investigation is necessary to determine if pharmacological agents designed to increase HDL can provide clinical benefit in diabetic patients. The effect of weight loss in patients with DM is also somewhat unclear as to if, and how much, weight loss is necessary to achieve clinically significant improvements in CV outcomes. Five percent weight loss may not be sufficient for diabetic patients with other CV risk factors and comorbidities. Further studies are needed to determine what amount of weight loss is needed attain CV benefit, and what the best treatment method is to reach that weight loss goal. Finally, follow-up regarding the new blood pressure guidelines, particularly in adults over 60 years who now fall under the higher systolic BP threshold, will need to be closely monitored moving forward.

CONCLUSION

As the prevalence of DM continues to rise, associated CVD - through both traditional CV risk factors and the direct effects of DM on CVD - can also be expected to rise. Accordingly, proper control and treatment of DM, along with aggressive treatment of associated CV risk factors is central to curbing the growing prevalence and progression of DM and CVD. Additional research is needed to better understand the disease process and its effects on CV health in order to improve medical management and CV outcomes in diabetic patients.

REFERENCES

1 **Wild S**, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004; **27**: 1047-1053 [PMID: 15111519 DOI: 10.2337/diacare.27.5.1047]

2 **Aguiree F**, Brown A, Cho NH, Dahlquist G, Dodd S, Dunning T, Hirst M, Hwang C, Magliano D, Patterson C. IDF Diabetes Atlas. 2013

3 **Bahia LR**, Araujo DV, Schaan BD, Dib SA, Negrato CA, Leão MP, Ramos AJ, Forti AC, Gomes MB, Foss MC, Monteiro RA, Sartorelli D, Franco LJ. The costs of type 2 diabetes mellitus outpatient care in the Brazilian public health system. *Value Health* 2011; **14**: S137-S140 [PMID: 21839888 DOI: 10.1016/j.jval.2011.05.009]

4 **American Diabetes Association**. Economic costs of diabetes in the U.S. In 2007. *Diabetes Care* 2008; **31**: 596-615 [PMID: 18308683 DOI: 10.2337/dc08-9017]

5 **Matheus AS**, Tannus LR, Cobas RA, Palma CC, Negrato CA, Gomes MB. Impact of diabetes on cardiovascular disease: an update. *Int J Hypertens* 2013; **2013**: 653789 [PMID: 23533715 DOI: 10.1155/2013/653789]

6 **Centers for Disease Control and Prevention**. National diabetes statistics report: Estimates of diabetes and its burden in the United States, 2014. Atlanta, GA: US Department of Health and Human Services, 2014

7 **Rivellese AA**, Riccardi G, Vaccaro O. Cardiovascular risk in women with diabetes. *Nutr Metab Cardiovasc Dis* 2010; **20**: 474-480 [PMID: 20621459 DOI: 10.1016/j.numecd.2010.01.008]

8 **Li YW**, Aronow WS. Diabetes mellitus and cardiovascular disease.

J Clinic Experiment Cardiol 2011; **2**: 2 [DOI: 10.4172/2155-9880.1000114]
9 **Duncan BB**, Schmidt MI, Pankow JS, Ballantyne CM, Couper D, Vigo A, Hoogeveen R, Folsom AR, Heiss G; Atherosclerosis Risk in Communities Study. Low-grade systemic inflammation and the development of type 2 diabetes: the atherosclerosis risk in communities study. *Diabetes* 2003; **52**: 1799-1805 [PMID: 12829649 DOI: 10.2337/diabetes.52.7.1799]
10 **Shoelson SE**, Lee J, Goldfine AB. Inflammation and insulin resistance. *J Clin Invest* 2006; **116**: 1793-1801 [PMID: 16823477 DOI: 10.1172/jci29069]
11 **Vicenová B**, Vopálenský V, Burýsek L, Pospísek M. Emerging role of interleukin-1 in cardiovascular diseases. *Physiol Res* 2009; **58**: 481-498 [PMID: 19093736]
12 **Barouch LA**, Berkowitz DE, Harrison RW, O'Donnell CP, Hare JM. Disruption of leptin signaling contributes to cardiac hypertrophy independently of body weight in mice. *Circulation* 2003; **108**: 754-759 [PMID: 12885755 DOI: 10.1161/01.cir.0000083716.82622.fd]
13 **Kim M**, Oh JK, Sakata S, Liang I, Park W, Hajjar RJ, Lebeche D. Role of resistin in cardiac contractility and hypertrophy. *J Mol Cell Cardiol* 2008; **45**: 270-280 [PMID: 18597775 DOI: 10.1016/j.yjmcc.2008.05.006]
14 **Chait A**, Han CY, Oram JF, Heinecke JW. Thematic review series: The immune system and atherogenesis. Lipoprotein-associated inflammatory proteins: markers or mediators of cardiovascular disease? *J Lipid Res* 2005; **46**: 389-403 [PMID: 15722558 DOI: 10.1194/jlr.R400017-JLR200]
15 **Ferrarezi DA**, Cheurfa N, Reis AF, Fumeron F, Velho G. Adiponectin gene and cardiovascular risk in type 2 diabetic patients: a review of evidences. *Arq Bras Endocrinol Metabol* 2007; **51**: 153-159 [PMID: 17505621 DOI: 10.1590/S0004-27302007000200003]
16 **Leahy JL**. Pathogenesis of type 2 diabetes mellitus. *Arch Med Res* 2005; **36**: 197-209 [PMID: 15925010 DOI: 10.1016/j.arcmed.2005.01.003]
17 **Belke DD**, Betuing S, Tuttle MJ, Graveleau C, Young ME, Pham M, Zhang D, Cooksey RC, McClain DA, Litwin SE, Taegtmeyer H, Severson D, Kahn CR, Abel ED. Insulin signaling coordinately regulates cardiac size, metabolism, and contractile protein isoform expression. *J Clin Invest* 2002; **109**: 629-639 [PMID: 11877471 DOI: 10.1172/jci13946]
18 The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. The Diabetes Control and Complications Trial Research Group. *N Engl J Med* 1993; **329**: 977-986 [PMID: 8366922 DOI: 10.1056/nejm199309303291401]
19 **Schena FP**, Gesualdo L. Pathogenetic mechanisms of diabetic nephropathy. *J Am Soc Nephrol* 2005; **16** Suppl 1: S30-S33 [PMID: 15938030 DOI: 10.1681/ASN.2004110970]
20 **Gesualdo L**, Ranieri E, Monno R, Rossiello MR, Colucci M, Semeraro N, Grandaliano G, Schena FP, Ursi M, Cerullo G. Angiotensin IV stimulates plasminogen activator inhibitor-1 expression in proximal tubular epithelial cells. *Kidney Int* 1999; **56**: 461-470 [PMID: 10432384 DOI: 10.1046/j.1523-1755.1999.00578.x]
21 **Wolf G**, Ziyadeh FN. The role of angiotensin II in diabetic nephropathy: emphasis on nonhemodynamic mechanisms. *Am J Kidney Dis* 1997; **29**: 153-163 [PMID: 9002545 DOI: 10.1016/S0272-6386(97)90023-8]
22 **Kannel WB**. Lipids, diabetes, and coronary heart disease: insights from the Framingham Study. *Am Heart J* 1985; **110**: 1100-1107 [PMID: 4061265 DOI: 10.1016/0002-8703(85)90224-8]
23 **Taskinen MR**. Diabetic dyslipidaemia: from basic research to clinical practice. *Diabetologia* 2003; **46**: 733-749 [PMID: 12774165 DOI: 10.1007/s00125-003-1111-y]
24 **Krauss RM**, Siri PW. Dyslipidemia in type 2 diabetes. *Med Clin North Am* 2004; **88**: 897-909, x [PMID: 15308384 DOI: 10.1016/j.mcna.2004.04.004]
25 **Solano MP**, Goldberg RB. Management of dyslipidemia in diabetes. *Cardiol Rev* 2006; **14**: 125-135 [PMID: 16628021 DOI: 10.1097/01.crd.0000188034.76283.5e]
26 **Chahil TJ**, Ginsberg HN. Diabetic dyslipidemia. *Endocrinol Metab Clin North Am* 2006; **35**: 491-510, vii-viii [PMID: 16959582 DOI: 10.1016/j.ecl.2006.06.002]
27 **Mooradian AD**, Albert SG, Haas MJ. Low serum high-density lipoprotein cholesterol in obese subjects with normal serum triglycerides: the role of insulin resistance and inflammatory cytokines. *Diabetes Obes Metab* 2007; **9**: 441-443 [PMID: 17391174 DOI: 10.1111/j.1463-1326.2006.00636.x]
28 **Hamilton SJ**, Watts GF. Endothelial dysfunction in diabetes: pathogenesis, significance, and treatment. *Rev Diabet Stud* 2013; **10**: 133-156 [PMID: 24380089 DOI: 10.1900/rds.2013.10.133]
29 **Asghar O**, Al-Sunni A, Khavandi K, Khavandi A, Withers S, Greenstein A, Heagerty AM, Malik RA. Diabetic cardiomyopathy. *Clin Sci* (Lond) 2009; **116**: 741-760 [PMID: 19364331 DOI: 10.1042/cs20080500]
30 **Galderisi M**, Anderson KM, Wilson PW, Levy D. Echocardiographic evidence for the existence of a distinct diabetic cardiomyopathy (the Framingham Heart Study). *Am J Cardiol* 1991; **68**: 85-89 [DOI: 10.1016/0002-9149(91)90716-X]
31 **Santra S**, Basu AK, Roychowdhury P, Banerjee R, Singhania P, Singh S, Datta UK. Comparison of left ventricular mass in normotensive type 2 diabetes mellitus patients with that in the nondiabetic population. *J Cardiovasc Dis Res* 2011; **2**: 50-56 [PMID: 21716753 DOI: 10.4103/0975-3583.78597]
32 **Eguchi K**, Boden-Albala B, Jin Z, Rundek T, Sacco RL, Homma S, Di Tullio MR. Association between diabetes mellitus and left ventricular hypertrophy in a multiethnic population. *Am J Cardiol* 2008; **101**: 1787-1791 [PMID: 18549860 DOI: 10.1016/j.amjcard.2008.02.082]
33 **Patil VC**, Patil HV, Shah KB, Vasani JD, Shetty P. Diastolic dysfunction in asymptomatic type 2 diabetes mellitus with normal systolic function. *J Cardiovasc Dis Res* 2011; **2**: 213-222 [PMID: 22135479 DOI: 10.4103/0975-3583.89805]
34 **Brooks BA**, Franjic B, Ban CR, Swaraj K, Yue DK, Celermajer DS, Twigg SM. Diastolic dysfunction and abnormalities of the microcirculation in type 2 diabetes. *Diabetes Obes Metab* 2008; **10**: 739-746 [PMID: 17941867 DOI: 10.1111/j.1463-1326.2007.00803.x]
35 **Shivalkar B**, Dhondt D, Goovaerts I, Van Gaal L, Bartunek J, Van Crombrugge P, Vrints C. Flow mediated dilatation and cardiac function in type 1 diabetes mellitus. *Am J Cardiol* 2006; **97**: 77-82 [PMID: 16377288 DOI: 10.1016/j.amjcard.2005.07.111]
36 **Sharma S**, Adrogue JV, Golfman L, Uray I, Lemm J, Youker K, Noon GP, Frazier OH, Taegtmeyer H. Intramyocardial lipid accumulation in the failing human heart resembles the lipotoxic rat heart. *FASEB J* 2004; **18**: 1692-1700 [PMID: 15522914 DOI: 10.1096/fj.04-2263com]
37 **McGavock JM**, Lingvay I, Zib I, Tillery T, Salas N, Unger R, Levine BD, Raskin P, Victor RG, Szczepaniak LS. Cardiac steatosis in diabetes mellitus: a 1H-magnetic resonance spectroscopy study. *Circulation* 2007; **116**: 1170-1175 [PMID: 17698735 DOI: 10.1161/circulationaha.106.645614]
38 **Rijzewijk LJ**, van der Meer RW, Smit JW, Diamant M, Bax JJ, Hammer S, Romijn JA, de Roos A, Lamb HJ. Myocardial steatosis is an independent predictor of diastolic dysfunction in type 2 diabetes mellitus. *J Am Coll Cardiol* 2008; **52**: 1793-1799 [PMID: 19022158 DOI: 10.1016/j.jacc.2008.07.062]
39 **Aasum E**, Hafstad AD, Severson DL, Larsen TS. Age-dependent changes in metabolism, contractile function, and ischemic sensitivity in hearts from db/db mice. *Diabetes* 2003; **52**: 434-441 [PMID: 12540618 DOI: 10.2337/diabetes.52.2.434]
40 **Fang ZY**, Schull-Meade R, Leano R, Mottram PM, Prins JB, Marwick TH. Screening for heart disease in diabetic subjects. *Am Heart J* 2005; **149**: 349-354 [PMID: 15846276 DOI: 10.1016/j.ahj.2004.06.021]
41 **Yu CM**, Chau E, Sanderson JE, Fan K, Tang MO, Fung WH, Lin H, Kong SL, Lam YM, Hill MR, Lau CP. Tissue Doppler echocardiographic evidence of reverse remodeling and improved synchronicity by simultaneously delaying regional contraction after biventricular pacing therapy in heart failure. *Circulation* 2002; **105**:

438-445 [PMID: 11815425 DOI: 10.1161/hc0402.102623]
42 **Ng AC**, Delgado V, Bertini M, van der Meer RW, Rijzewijk LJ, Hooi Ewe S, Siebelink HM, Smit JW, Diamant M, Romijn JA, de Roos A, Leung DY, Lamb HJ, Bax JJ. Myocardial steatosis and biventricular strain and strain rate imaging in patients with type 2 diabetes mellitus. *Circulation* 2010; **122**: 2538-2544 [PMID: 21126971 DOI: 10.1161/CIRCULATIONAHA.110.955542]
43 **Ng AC**, Delgado V, Bertini M, van der Meer RW, Rijzewijk LJ, Shanks M, Nucifora G, Smit JW, Diamant M, Romijn JA, de Roos A, Leung DY, Lamb HJ, Bax JJ. Findings from left ventricular strain and strain rate imaging in asymptomatic patients with type 2 diabetes mellitus. *Am J Cardiol* 2009; **104**: 1398-1401 [PMID: 19892057 DOI: 10.1016/j.amjcard.2009.06.063]
44 **Ernande L**, Rietzschel ER, Bergerot C, De Buyzere ML, Schnell F, Groisne L, Ovize M, Croisille P, Moulin P, Gillebert TC, Derumeaux G. Impaired myocardial radial function in asymptomatic patients with type 2 diabetes mellitus: a speckle-tracking imaging study. *J Am Soc Echocardiogr* 2010; **23**: 1266-1272 [PMID: 20932716 DOI: 10.1016/j.echo.2010.09.007]
45 **Scognamiglio R**, Avogaro A, Casara D, Crepaldi C, Marin M, Palisi M, Mingardi R, Erle G, Fasoli G, Dalla Volta S. Myocardial dysfunction and adrenergic cardiac innervation in patients with insulin-dependent diabetes mellitus. *J Am Coll Cardiol* 1998; **31**: 404-412 [PMID: 9462586 DOI: 10.1016/S0735-1097(97)00516-0]
46 **Regan TJ**, Lyons MM, Ahmed SS, Levinson GE, Oldewurtel HA, Ahmad MR, Haider B. Evidence for cardiomyopathy in familial diabetes mellitus. *J Clin Invest* 1977; **60**: 884-899 [PMID: 893679 DOI: 10.1172/jci108843]
47 **Tribouilloy C**, Rusinaru D, Mahjoub H, Tartière JM, Kesri-Tartière L, Godard S, Peltier M. Prognostic impact of diabetes mellitus in patients with heart failure and preserved ejection fraction: a prospective five-year study. *Heart* 2008; **94**: 1450-1455 [PMID: 18208832 DOI: 10.1136/hrt.2007.128769]
48 **Magri CJ**, Cassar A, Fava S, Felice H. Heart failure with preserved ejection fraction and diabetes mellitus. *J Diab Res Clin Met* 2012; **1**: 2 [DOI: 10.7243/2050-0866-1-2]
49 **From AM**, Leibson CL, Bursi F, Redfield MM, Weston SA, Jacobsen SJ, Rodeheffer RJ, Roger VL. Diabetes in heart failure: prevalence and impact on outcome in the population. *Am J Med* 2006; **119**: 591-599 [PMID: 16828631 DOI: 10.1016/j.amjmed.2006.05.024]
50 **Dei Cas A**, Khan SS, Butler J, Mentz RJ, Bonow RO, Avogaro A, Tschoepe D, Doehner W, Greene SJ, Senni M, Gheorghiade M, Fonarow GC. Impact of diabetes on epidemiology, treatment, and outcomes of patients with heart failure. *JACC Heart Fail* 2015; **3**: 136-145 [PMID: 25660838 DOI: 10.1016/j.jchf.2014.08.004]
51 **Rolim LC**, Sá JRd, Chacra AR, Dib SA. Neuropatia autonômica cardiovascular diabética: fatores de risco, impacto clínico e diagnóstico precoce. *Arq Bras Cardiol* 2008; **90**: e24-e32
52 **Rolim LC**, Sá JR, Chacra AR, Dib SA. Diabetic cardiovascular autonomic neuropathy: risk factors, clinical impact and early diagnosis. *Arq Bras Cardiol* 2008; **90**: e24-e31 [PMID: 18516377 DOI: 10.1590/S0066-782X2008000400014]
53 **Prince CT**, Secrest AM, Mackey RH, Arena VC, Kingsley LA, Orchard TJ. Cardiovascular autonomic neuropathy, HDL cholesterol, and smoking correlate with arterial stiffness markers determined 18 years later in type 1 diabetes. *Diabetes Care* 2010; **33**: 652-657 [PMID: 20040653 DOI: 10.2337/dc09-1936]
54 **Vinik AI**, Ziegler D. Diabetic cardiovascular autonomic neuropathy. *Circulation* 2007; **115**: 387-397 [PMID: 17242296 DOI: 10.1161/circulationaha.106.634949]
55 **Kannel WB**, McGee DL. Diabetes and cardiovascular disease. The Framingham study. *JAMA* 1979; **241**: 2035-2038 [PMID: 430798 DOI: 10.1001/jama.1979.03290450033020]
56 **Fuller JH**, Shipley MJ, Rose G, Jarrett RJ, Keen H. Mortality from coronary heart disease and stroke in relation to degree of glycaemia: the Whitehall study. *Br Med J* (Clin Res Ed) 1983; **287**: 867-870 [PMID: 6412862 DOI: 10.1136/bmj.287.6396.867]
57 **Haffner SM**. Coronary heart disease in patients with diabetes. *N Engl J Med* 2000; **342**: 1040-1042 [PMID: 10749967 DOI: 10.1056/nejm200004063421408]
58 **Williams IL**, Noronha B, Zaman AG. Review: The management of acute myocardial infarction in patients with diabetes mellitus. *BJDVD* 2003; **3**: 319-324 [DOI: 10.1177/14746514030030050201]
59 **Vinik AI**, Erbas T, Park TS, Nolan R, Pittenger GL. Platelet dysfunction in type 2 diabetes. *Diabetes Care* 2001; **24**: 1476-1485 [PMID: 11473089 DOI: 10.2337/diacare.24.8.1468]
60 **Vischer UM**, Emeis JJ, Bilo HJ, Stehouwer CD, Thomsen C, Rasmussen O, Hermansen K, Wollheim CB, Ingerslev J. von Willebrand factor (vWf) as a plasma marker of endothelial activation in diabetes: improved reliability with parallel determination of the vWf propeptide (vWf: AgII). *Thromb Haemost* 1998; **80**: 1002-1007 [PMID: 9869174]
61 **Sobel BE**, Woodcock-Mitchell J, Schneider DJ, Holt RE, Marutsuka K, Gold H. Increased plasminogen activator inhibitor type 1 in coronary artery atherectomy specimens from type 2 diabetic compared with nondiabetic patients: a potential factor predisposing to thrombosis and its persistence. *Circulation* 1998; **97**: 2213-2221 [PMID: 9631870 DOI: 10.1161/01.CIR.97.22.2213]
62 **Ceriello A**, Giugliano D, Quatraro A, Marchi E, Barbanti M, Lefèbvre P. Evidence for a hyperglycaemia-dependent decrease of antithrombin III-thrombin complex formation in humans. *Diabetologia* 1990; **33**: 163-167 [PMID: 2184068 DOI: 10.1007/BF00404044]
63 **Boras J**, Brkljačić N, Ljubičić A, Ljubić S. Silent ischemia and diabetes mellitus. *Diabetologia Croatica* 2010; **39**: 57-65
64 **Wackers FJ**, Young LH, Inzucchi SE, Chyun DA, Davey JA, Barrett EJ, Taillefer R, Wittlin SD, Heller GV, Filipchuk N, Engel S, Ratner RE, Iskandrian AE. Detection of silent myocardial ischemia in asymptomatic diabetic subjects: the DIAD study. *Diabetes Care* 2004; **27**: 1954-1961 [PMID: 15277423 DOI: 10.2337/diacare.27.8.1954]
65 **Fazzini PF**, Prati PL, Rovelli F, Antoniucci D, Menghini F, Seccareccia F, Menotti A. Epidemiology of silent myocardial ischemia in asymptomatic middle-aged men (the ECCIS Project). *Am J Cardiol* 1993; **72**: 1383-1388 [PMID: 8256731 DOI: 10.1016/0002-9149(93)90184-E]
66 **Koistinen MJ**. Prevalence of asymptomatic myocardial ischaemia in diabetic subjects. *BMJ* 1990; **301**: 92-95 [PMID: 2390590 DOI: 10.1136/bmj.301.6743.92]
67 **Ziegler D**, Gries FA, Spüler M, Lessmann F. The epidemiology of diabetic neuropathy. Diabetic Cardiovascular Autonomic Neuropathy Multicenter Study Group. *J Diabetes Complications* 1992; **6**: 49-57 [PMID: 1562759 DOI: 10.1016/1056-8727(92)90049-Q]
68 **O'Brien IA**, O'Hare JP, Lewin IG, Corrall RJ. The prevalence of autonomic neuropathy in insulin-dependent diabetes mellitus: a controlled study based on heart rate variability. *Q J Med* 1986; **61**: 957-967 [PMID: 3628708]
69 **Garber AJ**, Abrahamson MJ, Barzilay JI, Blonde L, Bloomgarden ZT, Bush MA, Dagogo-Jack S, Davidson MB, Einhorn D, Garvey WT, Grunberger G, Handelsman Y, Hirsch IB, Jellinger PS, McGill JB, Mechanick JI, Rosenblit PD, Umpierrez GE, Davidson MH. American Association of Clinical Endocrinologists' comprehensive diabetes management algorithm 2013 consensus statement--executive summary. *Endocr Pract* 2013; **19**: 536-557 [PMID: 23816937 DOI: 10.4158/ep13176.cs]
70 **Skyler JS**, Bergenstal R, Bonow RO, Buse J, Deedwania P, Gale EA, Howard BV, Kirkman MS, Kosiborod M, Reaven P, Sherwin RS. Intensive glycemic control and the prevention of cardiovascular events: implications of the ACCORD, ADVANCE, and VA diabetes trials: a position statement of the American Diabetes Association and a scientific statement of the American College of Cardiology Foundation and the American Heart Association. *Circulation* 2009; **119**: 351-357 [PMID: 19095622 DOI: 10.1161/circulationaha.108.191305]
71 **Pogach L**, Conlin PR, Hobbs C, Vigersky RA. VA-DoD Update of Diabetes Guidelines: What Clinicians Need to Know About Absolute Risk of Benefits and Harms and A1c Laboratory Accuracy. Federal Practitioner, 2011
72 **King P**, Peacock I, Donnelly R. The UK prospective diabetes study

(UKPDS): clinical and therapeutic implications for type 2 diabetes. *Br J Clin Pharmacol* 1999; **48**: 643-648 [PMID: 10594464 DOI: 10.1046/j.1365-2125.1999.00092.x]

73 **Duckworth WC**, McCarren M, Abraira C. Glucose control and cardiovascular complications: the VA Diabetes Trial. *Diabetes Care* 2001; **24**: 942-945 [PMID: 11347758]

74 **Patel A**, MacMahon S, Chalmers J, Neal B, Billot L, Woodward M, Marre M, Cooper M, Glasziou P, Grobbee D, Hamet P, Harrap S, Heller S, Liu L, Mancia G, Mogensen CE, Pan C, Poulter N, Rodgers A, Williams B, Bompoint S, de Galan BE, Joshi R, Travert F. Intensive blood glucose control and vascular outcomes in patients with type 2 diabetes. *N Engl J Med* 2008; **358**: 2560-2572 [PMID: 18539916]

75 **Riddle MC**. Effects of intensive glucose lowering in the management of patients with type 2 diabetes mellitus in the Action to Control Cardiovascular Risk in Diabetes (ACCORD) trial. *Circulation* 2010; **122**: 844-846 [PMID: 20733112 DOI: 10.1161/circulationaha.110.960138]

76 **Writing Team for the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group**. Sustained effect of intensive treatment of type 1 diabetes mellitus on development and progression of diabetic nephropathy: the Epidemiology of Diabetes Interventions and Complications (EDIC) study. *JAMA* 2003; **290**: 2159-2167 [PMID: 14570951 DOI: 10.1001/jama.290.16.2159]

77 **Jensen MD**, Ryan DH, Apovian CM, Ard JD, Comuzzie AG, Donato KA, Hu FB, Hubbard VS, Jakicic JM, Kushner RF, Loria CM, Millen BE, Nonas CA, Pi-Sunyer FX, Stevens J, Stevens VJ, Wadden TA, Wolfe BM, Yanovski SZ, Jordan HS, Kendall KA, Lux LJ, Mentor-Marcel R, Morgan LC, Trisolini MG, Wnek J, Anderson JL, Halperin JL, Albert NM, Bozkurt B, Brindis RG, Curtis LH, DeMets D, Hochman JS, Kovacs RJ, Ohman EM, Pressler SJ, Sellke FW, Shen WK, Smith SC, Tomaselli GF. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. *Circulation* 2014; **129**: S102-S138 [PMID: 24222017 DOI: 10.1161/01.cir.0000437739.71477.ee]

78 **Knowler WC**, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, Nathan DM. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 2002; **346**: 393-403 [PMID: 11832527 DOI: 10.1056/NEJMoa012512]

79 **Tuomilehto J**, Lindström J, Eriksson JG, Valle TT, Hämäläinen H, Ilanne-Parikka P, Keinänen-Kiukaanniemi S, Laakso M, Louheranta A, Rastas M, Salminen V, Uusitupa M. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med* 2001; **344**: 1343-1350 [PMID: 11333990 DOI: 10.1056/nejm200105033441801]

80 **Wing RR**. Long-term effects of a lifestyle intervention on weight and cardiovascular risk factors in individuals with type 2 diabetes mellitus: four-year results of the Look AHEAD trial. *Arch Intern Med* 2010; **170**: 1566-1575 [PMID: 20876408 DOI: 10.1001/archinternmed.2010.334]

81 **O'Neil PM**, Smith SR, Weissman NJ, Fidler MC, Sanchez M, Zhang J, Raether B, Anderson CM, Shanahan WR. Randomized placebo-controlled clinical trial of lorcaserin for weight loss in type 2 diabetes mellitus: the BLOOM-DM study. *Obesity* (Silver Spring) 2012; **20**: 1426-1436 [PMID: 22421927 DOI: 10.1038/oby.2012.66]

82 **Sjöström L**, Lindroos AK, Peltonen M, Torgerson J, Bouchard C, Carlsson B, Dahlgren S, Larsson B, Narbro K, Sjöström CD, Sullivan M, Wedel H. Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. *N Engl J Med* 2004; **351**: 2683-2693 [PMID: 15616203 DOI: 10.1056/NEJMoa035622]

83 **James WP**, Caterson ID, Coutinho W, Finer N, Van Gaal LF, Maggioni AP, Torp-Pedersen C, Sharma AM, Shepherd GM, Rode RA, Renz CL. Effect of sibutramine on cardiovascular outcomes in overweight and obese subjects. *N Engl J Med* 2010; **363**: 905-917 [PMID: 20818901 DOI: 10.1056/NEJMoa1003114]

84 **Wing RR**, Bolin P, Brancati FL, Bray GA, Clark JM, Coday M, Crow RS, Curtis JM, Egan CM, Espeland MA, Evans M, Foreyt JP, Ghazarian S, Gregg EW, Harrison B, Hazuda HP, Hill JO, Horton ES, Hubbard VS, Jakicic JM, Jeffery RW, Johnson KC, Kahn SE, Kitabchi AE, Knowler WC, Lewis CE, Maschak-Carey BJ, Montez MG, Murillo A, Nathan DM, Patricio J, Peters A, Pi-Sunyer X, Pownall H, Reboussin D, Regensteiner JG, Rickman AD, Ryan DH, Safford M, Wadden TA, Wagenknecht LE, West DS, Williamson DF, Yanovski SZ. Cardiovascular effects of intensive lifestyle intervention in type 2 diabetes. *N Engl J Med* 2013; **369**: 145-154 [PMID: 23796131 DOI: 10.1056/NEJMoa1212914]

85 Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38. UK Prospective Diabetes Study Group. *BMJ* 1998; **317**: 703-713 [PMID: 9732337 DOI: 10.1136/bmj.317.7160.703]

86 **Cushman WC**, Evans GW, Byington RP, Goff DC, Grimm RH, Cutler JA, Simons-Morton DG, Basile JN, Corson MA, Probstfield JL, Katz L, Peterson KA, Friedewald WT, Buse JB, Bigger JT, Gerstein HC, Ismail-Beigi F. Effects of intensive blood-pressure control in type 2 diabetes mellitus. *N Engl J Med* 2010; **362**: 1575-1585 [PMID: 20228401 DOI: 10.1056/NEJMoa1001286]

87 **James PA**, Oparil S, Carter BL, Cushman WC, Dennison-Himmelfarb C, Handler J, Lackland DT, LeFevre ML, MacKenzie TD, Ogedegbe O, Smith SC, Svetkey LP, Taler SJ, Townsend RR, Wright JT, Narva AS, Ortiz E. 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). *JAMA* 2014; **311**: 507-520 [PMID: 24352797]

88 **Whelton PK**, Barzilay J, Cushman WC, Davis BR, Iiamathi E, Kostis JB, Leenen FH, Louis GT, Margolis KL, Mathis DE, Moloo J, Nwachuku C, Panebianco D, Parish DC, Pressel S, Simmons DL, Thadani U. Clinical outcomes in antihypertensive treatment of type 2 diabetes, impaired fasting glucose concentration, and normoglycemia: Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial (ALLHAT). *Arch Intern Med* 2005; **165**: 1401-1409 [PMID: 15983290 DOI: 10.1001/archinte.165.12.1401]

89 **Turnbull F**, Neal B, Algert C, Chalmers J, Chapman N, Cutler J, Woodward M, MacMahon S. Effects of different blood pressure-lowering regimens on major cardiovascular events in individuals with and without diabetes mellitus: results of prospectively designed overviews of randomized trials. *Arch Intern Med* 2005; **165**: 1410-1419 [PMID: 15983291 DOI: 10.1001/archinte.165.12.1410]

90 **Krakoff LR**, Gillespie RL, Ferdinand KC, Fergus IV, Akinboboye O, Williams KA, Walsh MN, Bairey Merz CN, Pepine CJ. 2014 hypertension recommendations from the eighth joint national committee panel members raise concerns for elderly black and female populations. *J Am Coll Cardiol* 2014; **64**: 394-402 [PMID: 25060376 DOI: 10.1016/j.jacc.2014.06.014]

91 **Watts GF**, Playford DA. Dyslipoproteinaemia and hyperoxidative stress in the pathogenesis of endothelial dysfunction in non-insulin dependent diabetes mellitus: an hypothesis. *Atherosclerosis* 1998; **141**: 17-30 [PMID: 9863535 DOI: 10.1016/S0021-9150(98)00170-1]

92 **Matheus AS**, Cobas RA, Gomes MB. [Dyslipidemias in type 1 diabetes: a current approach]. *Arq Bras Endocrinol Metabol* 2008; **52**: 334-339 [PMID: 18438544 DOI: 10.1590/S0004-27302008000200021]

93 **Stone NJ**, Robinson JG, Lichtenstein AH, Bairey Merz CN, Blum CB, Eckel RH, Goldberg AC, Gordon D, Levy D, Lloyd-Jones DM, McBride P, Schwartz JS, Shero ST, Smith SC, Watson K, Wilson PW, Eddleman KM, Jarrett NM, LaBresh K, Nevo L, Wnek J, Anderson JL, Halperin JL, Albert NM, Bozkurt B, Brindis RG, Curtis LH, DeMets D, Hochman JS, Kovacs RJ, Ohman EM, Pressler SJ, Sellke FW, Shen WK, Smith SC, Tomaselli GF. 2013 ACC/AHA guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation* 2014; **129**: S1-45 [PMID:

24222016 DOI: 10.1161/01.cir.0000437738.63853.7a]
94 **Colhoun HM**, Betteridge DJ, Durrington PN, Hitman GA, Neil HA, Livingstone SJ, Thomason MJ, Mackness MI, Charlton-Menys V, Fuller JH. Primary prevention of cardiovascular disease with atorvastatin in type 2 diabetes in the Collaborative Atorvastatin Diabetes Study (CARDS): multicentre randomised placebo-controlled trial. *Lancet* 2004; **364**: 685-696 [PMID: 15325833 DOI: 10.1016/s0140-6736(04)16895-5]
95 **LaRosa JC**, Grundy SM, Waters DD, Shear C, Barter P, Fruchart JC, Gotto AM, Greten H, Kastelein JJ, Shepherd J, Wenger NK. Intensive lipid lowering with atorvastatin in patients with stable coronary disease. *N Engl J Med* 2005; **352**: 1425-1435 [PMID: 15755765 DOI: 10.1056/NEJMoa050461]
96 **Wanner C**, Krane V, März W, Olschewski M, Mann JF, Ruf G, Ritz E. Atorvastatin in patients with type 2 diabetes mellitus undergoing hemodialysis. *N Engl J Med* 2005; **353**: 238-248 [PMID: 16034009 DOI: 10.1056/NEJMoa043545]
97 **Keech A**, Simes RJ, Barter P, Best J, Scott R, Taskinen MR, Forder P, Pillai A, Davis T, Glasziou P, Drury P, Kesäniemi YA, Sullivan D, Hunt D, Colman P, d'Emden M, Whiting M, Ehnholm C, Laakso M. Effects of long-term fenofibrate therapy on cardiovascular events in 9795 people with type 2 diabetes mellitus (the FIELD study): randomised controlled trial. *Lancet* 2005; **366**: 1849-1861 [PMID: 16310551 DOI: 10.1016/s0140-6736(05)67667-2]
98 **Brown BG**, Zhao XQ, Chait A, Fisher LD, Cheung MC, Morse JS, Dowdy AA, Marino EK, Bolson EL, Alaupovic P, Frohlich J, Albers JJ. Simvastatin and niacin, antioxidant vitamins, or the combination for the prevention of coronary disease. *N Engl J Med* 2001; **345**: 1583-1592 [PMID: 11757504 DOI: 10.1056/NEJMoa011090]
99 **Boden WE**, Probstfield JL, Anderson T, Chaitman BR, Desvignes-Nickens P, Koprowicz K, McBride R, Teo K, Weintraub W. Niacin in patients with low HDL cholesterol levels receiving intensive statin therapy. *N Engl J Med* 2011; **365**: 2255-2267 [PMID: 22085343 DOI: 10.1056/NEJMoa1107579]
100 **Cannon CP**, Blazing MA, Giugliano RP, McCagg A, White JA, Theroux P, Darius H, Lewis BS, Ophuis TO, Jukema JW, De Ferrari GM, Ruzyllo W, De Lucca P, Im K, Bohula EA, Reist C, Wiviott SD, Tershakovec AM, Musliner TA, Braunwald E, Califf RM. Ezetimibe Added to Statin Therapy after Acute Coronary Syndromes. *N Engl J Med* 2015; **372**: 2387-2397 [PMID: 26039521 DOI: 10.1056/NEJMoa1410489]
101 **Shah RV**, Goldfine AB. Statins and risk of new-onset diabetes mellitus. *Circulation* 2012; **126**: e282-e284 [PMID: 23109518 DOI: 10.1161/circulationaha.112.122135]
102 **Pop-Busui R**. Cardiac autonomic neuropathy in diabetes: a clinical perspective. *Diabetes Care* 2010; **33**: 434-441 [PMID: 20103559 DOI: 10.2337/dc09-1294]
103 The effect of intensive diabetes therapy on measures of autonomic nervous system function in the Diabetes Control and Complications Trial (DCCT). *Diabetologia* 1998; **41**: 416-423 [PMID: 9562345 DOI: 10.1007/s001250050924]
104 **Gaede P**, Vedel P, Larsen N, Jensen GV, Parving HH, Pedersen O. Multifactorial intervention and cardiovascular disease in patients with type 2 diabetes. *N Engl J Med* 2003; **348**: 383-393 [PMID: 12556541 DOI: 10.1056/NEJMoa021778]
105 **Zhang X**, Chen C. A new insight of mechanisms, diagnosis and treatment of diabetic cardiomyopathy. *Endocrine* 2012; **41**: 398-409 [PMID: 22322947 DOI: 10.1007/s12020-012-9623-1]
106 **Kajstura J**, Fiordaliso F, Andreoli AM, Li B, Chimenti S, Medow MS, Limana F, Nadal-Ginard B, Leri A, Anversa P. IGF-1 overexpression inhibits the development of diabetic cardiomyopathy and angiotensin II-mediated oxidative stress. *Diabetes* 2001; **50**: 1414-1424 [PMID: 11375343 DOI: 10.2337/diabetes.50.6.1414]
107 **Leri A**, Liu Y, Wang X, Kajstura J, Malhotra A, Meggs LG, Anversa P. Overexpression of insulin-like growth factor-1 attenuates the myocyte renin-angiotensin system in transgenic mice. *Circ Res* 1999; **84**: 752-762 [PMID: 10205143 DOI: 10.1161/01.RES.84.7.752]
108 **Ren J**, Samson WK, Sowers JR. Insulin-like growth factor I as a cardiac hormone: physiological and pathophysiological implications in heart disease. *J Mol Cell Cardiol* 1999; **31**: 2049-2061 [PMID: 10591031 DOI: 10.1006/jmcc.1999.1036]
109 **Norby FL**, Wold LE, Duan J, Hintz KK, Ren J. IGF-I attenuates diabetes-induced cardiac contractile dysfunction in ventricular myocytes. *Am J Physiol Endocrinol Metab* 2002; **283**: E658-E666 [PMID: 12217882 DOI: 10.1152/ajpendo.00003.2002]
110 **Ashraf H**, Boroumand MA, Amirzadegan A, Talesh SA, Davoodi G. Hemoglobin A1C in non-diabetic patients: an independent predictor of coronary artery disease and its severity. *Diabetes Res Clin Pract* 2013; **102**: 225-232 [PMID: 24176244 DOI: 10.1016/j.diabres.2013.10.011]
111 **Ollerton RL**, Playle R, Ahmed K, Dunstan FD, Luzio SD, Owens DR. Day-to-day variability of fasting plasma glucose in newly diagnosed type 2 diabetic subjects. *Diabetes Care* 1999; **22**: 394-398 [PMID: 10097916 DOI: 10.2337/diacare.22.3.394]
112 **Sacks DB**, Arnold M, Bakris GL, Bruns DE, Horvath AR, Kirkman MS, Lernmark A, Metzger BE, Nathan DM. Guidelines and recommendations for laboratory analysis in the diagnosis and management of diabetes mellitus. *Diabetes Care* 2011; **34**: e61-e99 [PMID: 21617108 DOI: 10.2337/dc11-9998]
113 **Petersen PH**, Jørgensen LG, Brandslund I, De Fine Olivarius N, Stahl M. Consequences of bias and imprecision in measurements of glucose and hba1c for the diagnosis and prognosis of diabetes mellitus. *Scand J Clin Lab Invest Suppl* 2005; **240**: 51-60 [PMID: 16112960 DOI: 10.1080/00365510500236135]

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