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COMMENTARY

Arterial stiffness and type 2 diabetes: dietary modulation after a single meal?

Shane A Phillips

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Diabetes is a risk factor for the development of hypertension, atherosclerotic heart disease, and is a major cause of morbidity and mortality throughout the world. There has been a dramatic increase in the incidence of insulin resistance in the past decade with global implications for the development of cardiovascular disease. In most forms of hypertension, the peripheral vascular resistance is increased in proportion to increases in blood pressure. In addition, vascular dysfunction may alter insulin-mediated glucose disposal, contributing to the development of insulin resistance and type 2 diabetes (Figure 1).[1,2] Poor glucose control seems to increase the risk of cardiovascular disease development during diabetes and recent evidence indicates that the postprandial state is an important contributing factor in the development of atherosclerosis.[3] During diabetes, the postprandial state is characterized by dramatic increase in blood glucose making the relationship between postprandial glucose and vascular function an important physiological consideration in the assessment of cardiovascular risk in patients with diabetes.

As hypertension is characterized by functional and structural changes in the vasculature, arterial testing of the peripheral circulation is critical for cardiovascular risk assessment during type 2 diabetes. It is important to note that noninvasive clinical testing for cardiovascular risk assessment can be used to determine structural and functional changes that are early clinical predictors of the development of hypertension and atherosclerotic cardiovascular disease. For example, previous studies indicate that there is impaired endothelium-dependent vasodilation (an early marker of the propensity for cardiovascular disease) in patients with diabetes.[4] Furthermore, even a single high sugar load is associated with impaired endothelial function,[5] suggesting that elevations in glucose or diabetes-associated alterations in glucose metabolism are the likely mechanism(s) linking diabetes and vascular dysfunction. The effect of hyperglycemia is linked to an increase in glucose-stimulated reactive oxygen species generation with subsequent lowering of nitric oxide production, as antioxidants that scavenge reactive oxygen species (vitamin C) have been shown to protect against impaired endothelium-dependent flow-mediated dilation responses in diabetes.[5] Importantly, oxidative stress during diabetes and chronic hypertension may contribute to hypertrophy in the vascular wall by inactivating nitric oxide and reducing the growth inhibitory effects of nitric oxide on smooth muscle cells.[6]

CONSIDERATIONS OF POSTPRANDIAL RESULTS

Awareness of the link between diet, obesity and type 2 diabetes sparked an interest in the dietary weight loss and nutritional strategies for the protection against cardiovascular disease. Unfortunately, the relationship between postprandial metabolism, vascular stiffness and cardiovascular risk in diabetes has been less well studied. There are a number of methods that have been used to assess elastic properties of arteries in humans. Pulse wave velocity (PWV) has been widely used to assess arterial stiffness, and augmentation index (AI) is an index of wave reflection that can also be used to estimate arterial stiffness. A high level of arterial stiffness (decreased compliance) causes an increase in PWV and an earlier return of the wave along the arterial tree. Previous studies have shown that there is an association between aortic PWV and glucose control in diabetes.[7] In this issue of *Hypertension Research*, Morioka *et al.*[8] investigated the effects of a single, standardized meal (500 calories) on changes in brachial-ankle PWV (baPWV) and cardio-ankle vascular index (CAVI) in patients with type 2 diabetes. There was a significant reduction in all indices of vascular stiffness (baPWV, CAVI and AI) at 120 min after meal ingestion. These results were potentially surprising in light of the relationship known between diabetes, nitric oxide and vascular stiffness during diabetes. Importantly, the authors found that systolic and diastolic blood pressure were reduced after meal ingestion and that the change in baPWV and AI (but not in CAVI) were correlated with changes in SBP and DBP.[8] Given that PWV and AI are dependent on blood pressure, this study highlights the importance of determining vascular stiffness in the context of stiffness indices less susceptible to changes in blood pressure (for example, CAVI) or in control healthy populations not at risk for the development of postprandial hypotension.

Postprandial reductions in blood pressure have been reported in patients with diabetes, and likely result from autonomic neuropathy of patients with diabetes. Although the mechanisms of postprandial lowering of blood pressure cannot be determined from this study, it is tempting to consider the role of insulin in altering vascular function.[9] Although insulin can vasodilate the arterial vasculature, lowering vascular resistance, this effect is often preceded by insulin-mediated changes in glucose uptake.[1] In the current study, the authors report a significant increase in postprandial insulin from baseline concomitant with blood pressure lowering

Dr Shane A Phillips is at the Departments of Physical Therapy and Medicine, University of Illinois at Chicago, 1919 W. Taylor Street M/C 898, Chicago, IL 60612, USA.
E-mail: shanep@uic.edu

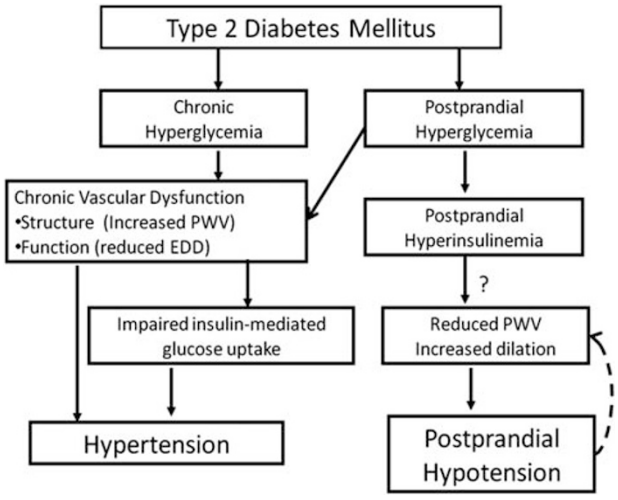

Figure 1 Physiological links between diabetes, arterial stiffness and arterial blood pressure.

(Figure 1).[8] However, the vasodilator effects of insulin in patients with type 2 diabetes (in the presence of obesity) are often impaired.[10] Importantly, patients who participated in the current study were lean (average body mass index: 23.3) and there were no apparent correlations found between changes in insulin and glucose, and changes in baBWV, AI or CAVI.[8] Although these results argue against the contribution of insulin in lower postprandial vascular stiffness, it may be important in future studies to determine the relationship(s) between postprandial blood pressure, insulin and vascular stiffness in diabetes and patients at risk for type 2 diabetes (pre-diabetes).

DIETARY IMPLICATIONS OF THE RESULTS

The results of the current study also show that a standard meal (51 g carbohydrate; 28 g fat; 10 g protein) can induce changes in vascular stiffness and postprandial hypotension. Previous studies have shown significant BP lowering after the consumption of a glucose drink (75 g), whereas BP remains the same after consumption of high fat or whey protein.[11] In addition, the magnitude of postprandial BP reduction seems to be greater with increased carbohydrate content, suggesting that postprandial hyperglycemia contributes to altered vascular stiffness and blood pressure after a single meal. The link between the magnitude of postprandial hyperglycemia and the risk of cardiovascular disease has been reported in other studies.[3] As improved postprandial hyperglycemia levels were associated with the regression of carotid medial intimal thickening (a commonly used direct assessment of early atherosclerosis),[12] it may be important to consider the dietary content (lower carbohydrate) in future studies seeking to evaluate the most effective strategies for lowering cardiovascular risk in patients with type 2 diabetes. Finally, it may be important to determine (in future studies) the value of postprandial hypotension and vascular stiffness in cardiovascular risk prevention strategies for patients with impaired glucose tolerance (pre-diabetes) and insulin resistance.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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