Original Research Article

Vitality of Pro-Inflammatory Cytokine, Scavenger Receptor Proteins and Atherosclerotic Plaque Markers in Risk Prediction of Diabetic Nephropathy

V. Khot¹, K.S. Yadav¹*, V.A. Haldankar¹ and A.K. Bhutey²

¹Department of Biochemistry, School of Medicine, D Y Patil University, Navi Mumbai-400706, India
²Dr.PDM Medical College, Amravati-444603, India

*Corresponding author

A B S T R A C T

Introduction

Diabetes has become a common global health problem that affects >170 million people worldwide. It is one of the leading causes of death and disability. World Health Organization estimated that by 2030 (Bethesda, 2007 and King et al., 1993), the number will rise to 366 million. DM is associated with long-term complications that affect almost every organ of the body, kidney, liver heart etc. T2DM is a complex polygenic disorder in which common genetic variants interact with environmental factors to unmask the disease.

Genetic factors are known to play an important role in the development of DN, atherosclerotic plaque etc (Eoin Brennan et al., 2013). Researchers found that plasma concentrations of inflammatory molecules including proinflammatory cytokines IL-6, IL-10 are elevated in diabetic patients (Pickup J. C., 1997). Recent studies have shown that concentrations of these substances increase with the progression of nephropathy (Bruno et al., 2003 and Krolewski et al., 2013). In this study the similar observations are observed.
Shikano et al., (2000), studied usefulness of IL-6 and IL10 diabetic nephropathy showed that increased adipose tissue IL-6 mRNA may be the cause of insulin resistant humans and the elevated mRNA levels correlated with reduced rates of insulin stimulated glucose disposal (Bastard et al., 2002) which further might progress into insulin resistance diabetes nephropathy.

Study done by researchers suggested that an adverse lipid profile might cause nephropathy in both type 1 and type 2 diabetic patients (Bonnet et al., 2000 and Chaturvedi et al., 2001). Single-gene (Mendelian) disorders with large effects (Proctor et al., 2006) are the most dramatic examples of the genetic contributions to lipid deposition in arteries. Dysregulation of cholesterol metabolism has also been linked to lipotoxicity and lipid accumulation in diabetes. Cholesterol influx into cells is mediated by several independent receptors, including scavenger receptor class A (SR-A1), class B (CD36), lectin-like oxLDL receptor-1 (LOX-1 or OLR-1 (Urahama, 2008), and LDL receptor (Nosadini et al., 2011). CD36 is a transmembrane protein of the class B scavenger receptor family and is involved in multiple biological processes (Febbraio et al., 2001). Abnormal lipoprotein metabolism noted by Hirano which stated that increased CVD risk lead to cause dyslipidemia is multifactorial and complex (Hirano, 2014).

Previous studies documented that all multiple lipoprotein abnormalities described in diabetic patients with nephropathy become more accentuated with increasing urinary albumin excretion (Gross et al., 2005). Hyperglycaemia-induced synthesis of CD36 protein in macrophages has been associated with increased uptake of ox-LDL by macrophages and foam cell formation in atherosclerotic lesions in people with diabetes. While diabetic cardiovascular complications are closely linked epidemiologically with albuminuria and DN, a role for CD36 in DN and renal pathophysiology has not to our knowledge been described to date (Febbraio et al., 2001). High ambient glucose has been shown to induce CD36 protein synthesis in macrophages (Griffin et al., 2001). CD36 expression in proximal tubular epithelial cell (PTECs) is associated with the diabetic condition and appears to be independent of degree of proteinuria and renal failure. Indeed, Susztak, et al., (2005) emphasized that increased CD36 expression in PTECs in DN was due to hyperglycemias, and concluded that high blood glucose stimulates CD36 expression in vitro (Susztak et al., 2005).

Literature survey found that researchers identified risk genes and loci associated with DN. So far, only several genes and loci have been identified, none of them showed a strong association with DN. However, DN is not clinically detectable until significant kidney damage has developed, highlighting the need to identify early-stage biomarkers. Therefore, a better study design with a larger sample size to identify candidate gene/s by expressions in DN are still needed.

Materials and Methods

In this study includes 241 subjects (118 male, 123 women, and age ranges 30-70 years) were included after screening for T2DM by measurement of blood glucose in fasting, post-prandial, glycosylated haemoglobin and microalbumin in urine. Subjects distributed after written consent and enrolled as per inclusion/exclusion criteria. All measurements before distribution were documented in data sheet. Categorization of subjects in three study groups were done on the basis of T2DM duration 3-5 years, Glycosylated
haemoglobin level (HbA1c) ≥ 7.0 % with fasting blood glucose ≥126 mg/dl) and microalbuminuria (30-300 mg/dl) in study group. Equal numbers of healthy volunteers enrolled in control group. Blood samples were processed for renal parameters & RT-PCR to check expressions of IL-6, IL-10, CD36 and LDLr.

Results and Discussion

Fasting blood glucose (FBS), Post- prandial blood glucose (PPBS), Glycosylated haemoglobin (A1C) and urinary microalbumin gives an idea about diabetes progression of individual. Since these are screening parameters for subject selection, there was a significant difference between control and study groups, p-value (<.00). In study group subjects no significant difference has been observed.

Diabetes and associated complications represent a significant health and economic burden, and given the emerging epidemics of obesity and diabetes in children and adolescents these increases in prevalence are expected to continue (Bethesda MD, 2007). Diagnosis of DN is typically made using clinical criteria (albuminuria, serum creatinine) rather than invasive renal biopsy.

Despite the large body of evidence for a heritable genetic component to nephropathy in type 1 and type 2 diabetes, the underlying genetic mechanisms remain poorly understood, with no robust DN candidate genes yet identified. Outcome of this study suggest that novel biomarker may play an important role in the progression and development of DN (Krolewski et al., 2013).

Study done by Nobuko Harita et al., (2009), showed that lower serum creatinine increased the risk of T2DM. Skeletal muscle is major target tissue of insulin and its resistance leads to the development of T2DM (Zierath et al., 2000). Creatinine is commonly used to determine GFR. In our study average serum creatinine reported within the normal range in control and study groups, similar findings were reported by Harita et al., (2009), urinary excretion of creatinine was almost two fold higher in both the study groups against the control group. Further post hoc analysis within study groups (<45 years and>45 years) irrespective of gender showed significant, p-value (<.00 and .00). In this study it was found no significant difference in urine creatinine was observed between control and study groups.

Micro-albuminuria is a gold standard parameter in diagnosis of renal diseases. Albumin/ creatinine ratio (ACR) is greater than or equal to 2.5 (men) or 3.5 (women), or albumin concentration greater than or equal to 20 mg/L is significant observation in diagnosis of renal diseases. Literature survey reveals that early stage of kidney disease demonstrates an abnormal ACR. This study reported marginally significant difference of ACR between control and study groups. Further post hoc analysis also showed similar observations between control, less than 45 years and above 45 years. These observations do not indicate any confirmatory outcome. So it was recommended to undertake study on a larger population to achieve final conclusion. After literature survey it was fond that ACR is an important marker in diagnosis of DN but values reported in this study does not support.

It was recommend by the American Diabetes Association and the National Institutes of Health that in all the people with diabetes for detection of kidney dysfunction, e-GFR must be calculated from serum Creatinine at least once a year. In this study e-GFR was calculated by MDRD (Modification of diet in renal disease) study group equation (Levey et
There is significant difference between control and study groups (p<.00). Further analysis by post hoc test within the study groups (<45 years and>45 years) and control showed significant difference, p-value (<.00). Therefore measurement of e-GFR is useful indicator in monitoring diabetic nephropathy associated with T2DM. All above statements are tabulated in table no 1 & 2.

IL-6 is one of the most extensively studied pro-inflammatory cytokines (Suzuki D, et al., 1995). Cortical mRNA expression of IL-6 is increased in diabetic kidney in comparison with normal rodents and is positively associated with elevated urinary concentrations of albumin (Navarro et al., 2006). Similarly, other researcher published work on interstitial expression of IL-6 mRNA in human renal tissue from individuals with diabetes, correlates with histological features of interstitial injury (Suzuki et al., 1995). IL-10, an important Th2 cytokine, exerts predominantly anti-inflammatory and immunosuppressive effects (Zimmet, 1999).

In present study Data analysed by SPSS showed positive expression of IL-6 and IL-10 in both the groups irrespective of gender. It indicates that there is inflammation and its degree of severity is correlated with renal injury in T2DM.

In this study descriptive statistics (table1) within groups showed significant difference only for HDL (P<.00) & LDL/HDL ratio (P<.00). All other lipid parameters p-values are non-significant. High density lipoprotein cholesterol (HDL-C) is protective against the development of coronary artery disease (CAD) and microalbuminuria (Zierath et al., 2000). In this study it was found similar results in HDL & HDL/LDL ratio. Cholesterol, triglyceride, LDL and VLDL levels disagreed with the outcomes of KMA Aziz et al., (2013) study on diabetic nephropathy. In this study high degree of significance, p value (<0.00-0.05) was found in proinflammatory cytokines (IL6 & IL10), scavenger receptor (CD36) protein and atherosclerotic (LDLr) in both study groups (Table1 and 2).

In 1995, Suzuki et al., (1995) reported that serum levels of IL-6 were significantly higher in patients with T2DN than the levels observed in diabetic patients without nephropathy, which suggests that IL-6 may have a role in the pathogenesis of DN. Later, Suzuki et al., (1995) performed situ hybridization of IL-6 in diabetic nephropathy, analyzed kidney biopsies in patients with DN by high-resolution in situ hybridization. Outcome of further experiment showed that cells infiltrating the mesangium, interstitium, and tubules were positive for mRNA encoding IL-6. Also they found a relationship between the severity of diabetic glomerulopathy (mesangial expansion) and expression of IL-6 mRNA in glomerular cells (mesangial cells and podocyte), which indicated that IL-6 may affect the dynamics of extracellular matrix surrounding those cells. Many in-vitro studies have confirmed that IL-6 affects extracellular matrix dynamics at mesangial and podocyte levels, stimulates mesangial cell proliferation, increases fibronectin expression, and enhances endothelial permeability. This mechanism has been proved in the development of kidney injury in patients with T2DM. Moreover, high serum and urinary concentrations of IL-6 are associated with greater albuminuria in patients with DN; however, serum and urinary levels do not correlate with each other (Shikano et al., 2000, and Navarro et al., 2006).

IL-10 plays an essential role in the pathogenesis of DN. Mesangial expansion has also been found to be attributable to hyperglycaemia related inflammation.
Mesangial cells are the major local source of IL-10 in the normal adult kidney. Several studies have demonstrated the association between up regulation of IL-10 and the pathophysiology of various kidney diseases such as mesangio-proliferative glomerulonephritis (Yano et al., 1997; Niemir et al., 1998; Sinuai et al., 2006). Increased serum levels of circulating IL-10 have been found and correlate with albuminuria and diabetic nephropathy. IL-10 plays an essential role in the pathogenesis of DN. These factors may slow down the course of diabetic nephropathy through a reduction of the inflammatory processes. The study done by Inna Sinuai et al., (2006) suggested that IL-10 gene expression and IL-10 induced signalling pathways have important role in the regulation and maintenance of normal renal function. In this study IL6 & IL10 expressions are observed which is relates to the conclusion of several research papers referred in literature. In this study it was found significant P-values of IL-6 & IL-10 (p<.000 -.005) in all study groups. Dyslipidimia is a risk factor for development and progression of microalbuminuria. In this study estimated lipids showed values within reference interval but LDLr & CD36 expressions were observed at an early stage of DN. High degree of significance was found in both LDLr and CD36 (p<.000) also, which was shown in table 3.

CD36 is a trans-membrane protein of the class b scavenger receptor family & is involved in multiple biological processes (Febbraio et al., 2001). High ambient glucose has been shown to induce CD36 protein synthesis in macrophages, because CD36 protein was markedly increased in proximal tubules in human diabetic nephropathy (Susztak et al., 2005). In our study similar findings has been noted with significant level of expressions in the study group compared to control, which indicate proximal tubular injury in subjects. Glycosylated hemoglobin and albuminuria compared with CD36 showed significant results which indicate that hyperglycemia in the blood circulation lead to progression of renal injury. CD36 is intimately involved in lipid metabolism and has been strongly implicated in pathological conditions associated with metabolic dis-regulation, including obesity, insulin resistance, diabetes, diabetic nephropathy and atherosclerosis (Febbraio et al., 2001 and, Griffin et al., 2001). The expressions of LDLr molecules involved in low-density lipoprotein receptor (LDLr) pathway and podocyte injury. The mean of LDL receptors observed expressed in this study, similar results were published by Laurence Duvillard et al., (2003).

CD36 is intimately involved in lipid metabolism and homoeostasis and has been strongly implicated in pathological conditions associated with metabolic dysregulation, including obesity, insulin resistance, diabetes, diabetic nephropathy and atherosclerosis (Suzuki et al., 1995 and, Yano et al., 1997). Circulating form of CD36 was identified in human plasma as a novel biomarker for T2DM (Handberg et al., 2006). Hyperglycaemia-induced synthesis of CD36 protein has been associated with increased uptake of LDL lead in atherosclerotic lesions in people with diabetes (Febbraio et al., 2001 and, Griffin et al., 2001). Researcher Susztak K, et al., (2005) reported a new functional role for CD36 scavenger receptor in tubular epithelial apoptosis associated with tubular degeneration and progression of DN. Thus CD36 could have a central role in triggering diabetic nephropathy which is one of the observations of this study. Despite immediate clinical implications for the treatment of people with kidney problems, this research may help in understanding how hyperglycaemia damages the kidney. In
particular, it highlights how important it is to keep blood glucose levels within reference range. A detailed review was published on role of novel gene biomarkers in early diagnosis of DN (Nahar et al., 2014).

**Table.1** Descriptive statistical analysis of renal parameters, and lipid parameters by R software within groups

<table>
<thead>
<tr>
<th>Study parameters</th>
<th>Study groups</th>
<th>Control</th>
<th>Control</th>
<th>45 years and less</th>
<th>45 years and less</th>
<th>More than 45 years</th>
<th>More than 45 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
</tr>
<tr>
<td>Urine Creatinine</td>
<td>60.99</td>
<td>4.335</td>
<td>121.06</td>
<td>9.231</td>
<td>134.65</td>
<td>13.960</td>
<td></td>
</tr>
<tr>
<td>Albumin/ creatinine ratio</td>
<td>0.44</td>
<td>2.113</td>
<td>3.35</td>
<td>3.56</td>
<td>3.56</td>
<td>2.623</td>
<td></td>
</tr>
<tr>
<td>Blood urea nitrogen</td>
<td>10.0</td>
<td>0.284</td>
<td>10.0</td>
<td>0.237</td>
<td>11.0</td>
<td>0.335</td>
<td></td>
</tr>
<tr>
<td>Uric Acid</td>
<td>4.8</td>
<td>0.112</td>
<td>5.0</td>
<td>0.203</td>
<td>5.3</td>
<td>0.139</td>
<td></td>
</tr>
<tr>
<td>Serum Creatinine</td>
<td>0.79</td>
<td>0.02</td>
<td>0.716</td>
<td>0.019</td>
<td>0.854</td>
<td>0.023</td>
<td></td>
</tr>
<tr>
<td>e-GFR</td>
<td>100</td>
<td>2.46</td>
<td>94.0</td>
<td>114</td>
<td>90.0</td>
<td>2.077</td>
<td></td>
</tr>
<tr>
<td>Total Cholesterol</td>
<td>117</td>
<td>2.73</td>
<td>178</td>
<td>5.9</td>
<td>190</td>
<td>4.68</td>
<td></td>
</tr>
<tr>
<td>Triglyceride</td>
<td>137</td>
<td>3.7</td>
<td>139</td>
<td>7.9</td>
<td>160</td>
<td>10.8</td>
<td></td>
</tr>
<tr>
<td>HDL Cholesterol</td>
<td>44.66</td>
<td>0.70</td>
<td>38.80</td>
<td>0.711</td>
<td>41.42</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Low density Lipoprotein</td>
<td>101.22</td>
<td>1.061</td>
<td>113.21</td>
<td>4.41</td>
<td>130.5</td>
<td>3.69</td>
<td></td>
</tr>
<tr>
<td>Cho/HDL ratio</td>
<td>5.04</td>
<td>0.121</td>
<td>4.64</td>
<td>0.135</td>
<td>4.79</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>LDL/HDL ratio</td>
<td>3.60</td>
<td>0.103</td>
<td>2.956</td>
<td>0.106</td>
<td>3.306</td>
<td>0.120</td>
<td></td>
</tr>
<tr>
<td>VLDL</td>
<td>27.59</td>
<td>0.704</td>
<td>27.828</td>
<td>1.59</td>
<td>32.1</td>
<td>2.17</td>
<td></td>
</tr>
</tbody>
</table>

**Table.2** P Value of Post Hoc Tests of renal parameters and lipid parameters within groups and between the groups (Tukey HSD).

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Control group &lt;45 yrs Control &gt;45 yrs</th>
<th>&lt;45 years group Control &gt;45 yrs</th>
<th>&gt;45 years group Control &lt;45 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum Creatinine</td>
<td>.034</td>
<td>.074</td>
<td>.034</td>
</tr>
<tr>
<td>ACR</td>
<td>.008</td>
<td>.420</td>
<td>.008</td>
</tr>
<tr>
<td>e-GFR</td>
<td>.00</td>
<td>.012</td>
<td>.00</td>
</tr>
<tr>
<td>BUN</td>
<td>.751</td>
<td>.040</td>
<td>.751</td>
</tr>
<tr>
<td>HDL Cholesterol</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>Triglyceride</td>
<td>.080</td>
<td>.086</td>
<td>.080</td>
</tr>
<tr>
<td>LDL/HDL ratio</td>
<td>.000</td>
<td>.138</td>
<td>.000</td>
</tr>
</tbody>
</table>

**Abbreviations:** SD: standard deviation, SE: standard error, PV: P value (Post hoc test). Data are mean + SD with range in parenthesis or absolute number of patients.
Table.3 Post hoc test between study groups and inflammatory markers (Tukey HSD)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Control group</th>
<th>&lt;45 years group</th>
<th>&gt;45 years group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;45 yrs</td>
<td>&gt;45 yrs</td>
<td>Control</td>
</tr>
<tr>
<td>CT of IL-6</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>CT of IL-10</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>CT of CD36</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>CT of LDLr</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
</tbody>
</table>

CT: threshold cycle quantification by rt-PCR.

It was concluded that early detection of renal injury in T2DM patients with routine biochemical parameters create dilemma. But when these results evaluated with gene expressions (IL-6, IL-10, CD36 and LDLr) and output of this exercise may help in confirmation of diagnosis. This observation strongly support risk prediction of DN. Early measurement of IL-6, IL-10, CD36 and LDLr may prevent morbidity & mortality. The present study was carried out in limited number of T2DM subjects. Further extensive research on large number of subjects with population diversity has been recommended.

Acknowledgement

We would like to express our sincere thanks to medical administrators, faculties and paramedical staff of D.Y. Patil Medical College, Navi Mumbai. We wish thanks to Dr Sakharam Muley for statistical analysis. Special thanks to the subjects who have participated in this research work, without their participation, this project would not have been possible.

References


Nosadini, R. and Tonolo, G. 2011. Role of oxidized low density lipoproteins and


