Evaluation of Co-Morbidity Impact of Diabetic Disorders on Some Haematological Profile of Patients Assayed in Port Harcourt, Niger Delta, Nigeria: A Public Health Concern

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Abstract

Introduction: Diabetes is a complex, metabolic disorder marked by either relative or absolute insulin deficiency that leads to irregular and ineffective glucose metabolism resulting to hyperglycaemia which could possibly affect the blood indices in humans. Anaemia is a health problem which signifies a considerable and under recognized burden in patients with chronic diabetes. White blood cell and platelet counts are markers of inflammation and thrombotic disorders (atherothrombosis) respectively which may possibly aid assessment of microvascular and macrovascular complications in diabetes.

Method: A descriptive cross-sectional study design and purposive sampling method was used to examine 50 diabetic and 50 non-diabetic subjects attending Christian Medical Centre, University of Port Harcourt Teaching Hospital and Braithwaite Memorial Specialist Hospital (BMSH) all in Port Harcourt, Rivers State, Nigeria. Male constituted 40% and female constituted 60% between the ages of 30-60 years (Mean 50 years) which comprised of 30 females and 20 males. The number of haematological parameters was 5. Hence, blood sample was collected into an anticoagulant ethylene diamine tetraacetic acid (EDTA) bottle A full blood count assay was performed on each sample and the results were analyzed using Graphpad calculator for analysis of the data. Parametric analysis using mean and Standard deviation was done for the variables. For the validation of observations, values below (P<0.05) were considered statistically significant.

Observation: The study revealed a significant (p<0.05) variation in the haematological parameters between the diabetic and control groups. Also, their white blood cell and platelet count varied significantly (p<0.05) within the diabetic group for male and females whereas, others showed no disparity (p>0.05).

Discussion: Anaemia is common in diabetes especially in diabetic nephropathy also; leucocytosis and thrombocytosis are likely occurrences in diabetes as evident in this study.

Conclusion: It is therefore, recommended to include full blood count as one of the routine laboratory tests required in the management of diabetic patients. The cross-sectional design of the study may not have shown causality. Furthermore, unforeseen confounders could likely have affected this present study in a way. Further research is necessary to confirm or refute the present findings and to elucidate the role of these blood indices in chronic diabetes.

Keywords: Haematological profile; Diabetes; Public health concern; Anaemia; Co-morbidity; Port harcourt; Niger delta

Introduction

Diabetes mellitus is a complex, chronic disease of public health importance globally. It is classified as a metabolic disorder in which the body does not produce enough or properly respond to insulin, a hormone produced in the pancreas (IDF Atlas, 2006). It is a complex metabolic derangement characterized by either relative or absolute insulin deficiency that results in disturbance of carbohydrate metabolism leading to excessive glucose in the blood, excretion of glucose in the urine, incomplete oxidation of fats and attending symptoms of thirst, polyuria and wasting remains some of the critical clinical evidence based outcomes [1].
Nonetheless, it is firmly a major health problem with clinical challenge that results in significant morbidity and mortality from diverse complications. It is estimated that over 170 million people worldwide are suffering from these global public health disease [2] and this represents about 2% of the world’s population literality. In Nigeria, about 1-7% of the population is affected, with over 90% of these being non-insulin dependent [3]. The morbidity and mortality associated with diabetes mellitus results from either acute or chronic complications. Moreover, chronic complications are known to give rise to microvascular disorder such as retinopathy, nephropathy, and neuropathy. Other chronic complications include macrovascular disorders such as atherosclerosis [4]. Atherosclerosis is a recognized major cause of mortality in the diabetic population [4] and it is implicated in the circulatory disturbances seen in diabetes disorder. The circulatory disturbances are further compounded by alteration in platelet count and activity, coagulopathy, fibrinolytic aberration, changes in endothelial metabolism, and haemorrhheological factors [5]. Based on these interactions of diabetes and other body systems, it has become apparent that the health of the affected populace is at risk of blindness/eye disease, excretory problem of the kidney, cardiovascular issues; this has caught a global attention thus, actions must have to be put in place to properly manage the situation and prevent the health issues where necessary. Initially, diabetes was seen as a societal problem of the socio-economic high class/status but recent evaluations have proven that even the middle/low class are at risk therefore, it is seen as an issue for both developed and developing countries of public health importance that calls for collaborative actions by local, regional and global health agencies.

Diabetes has been classified based on the clinical staging and etiology into type I and type II. Type I or Insulin dependent diabetes mellitus (IDDM) or juvenile on-set diabetes is characterized by beta cell destruction leading to absolute insulin deficiency, which may be due to autoimmune mechanism and patients are prone to ketoacidosis [6]. Type 11 or non-insulin dependent diabetes mellitus (NDDM) or adult onset diabetes is predominated by insulin resistance with relative insulin deficiency or an insulin secretory defect. Symptoms of diabetes are polyuria (frequent urination), polydipsia (increased thirst) and polyphagia (increased hunger). Symptoms may develop rapidly (weeks or months) in type 1 diabetes while in type-2 diabetes they usually develop much more slowly and may be subtle or absent respectively. Hyperglycemia is a common effect of uncontrolled diabetes and overtime leads to serious damage to many of the body’s system especially the nerves and blood vessels.

The increasing prevalence of diabetes mellitus had generated much concern because the disease puts those afflicted at risk for systems in particular the blood vessels disorder [7]. Most chronic diabetes outcomes are as a result of vascular complications both at macro vascular and micro vascular levels [8]. Recurrent or persistent hyperglycemia during diabetes causes glycation of body proteins which in turn leads to secondary complications affecting eyes, kidneys, nerves and arteries. Glycosylation and stiffening of red blood cells, may be responsible for, or associated with, large vessel disease in diabetes [9]. In diabetes, reduced haemoglobin has been reported which may be accompanied by a fall in the red blood cell count and packed cell volume parameters [10].

Haematological Indices are important parameters for the evaluation of size, number and maturity of the different blood cells in a specific volume of blood. It is important for the evaluation and management of patients with diabetes mellitus; it plays a vital role in our immune system and can be used to determine many abnormalities with either the production or destruction of blood cells. Furthermore, several haematological changes affecting the red blood cells, white blood cells and the coagulation factors are shown to be associated with diabetes mellitus. Some of these are directly related to the diabetic state, while others are simply accidental with the ailment.

Anaemia is one of implications of diabetes, various forms of anaemia have been reported to occur in patients with diabetes mellitus and some of which result as an impediment of long term diabetes, affecting iron uptake as well as its consumption of iron, secondly; absorption of nutrient in the gastro intestinal tract and as a result of diabetic nephropathy are all factors. On the other hand, studies had shown that elevated glucose level may provoke anaemia and consequently diabetes may perhaps be one of the crucial cause of anaemia. Also, the anaemia associated with diabetic kidney disease is proportional to over 50% of the renal failure, it is usually normocytic and normochromic.

Nevertheless, in the case of iron deficiency anaemia microcytic and hypochromic red cells may possibly be seen. Reticulocyte blood index is reduced in diabetes; the reticulocytopenia seen in diabetes is said to be due to bone marrow suppression. Also, anaemia in diabetes might result from mal-absorption due to development of gastrointestinal neuropathy. In addition, diabetic patients experience changes in ph and in the levels of 2,3-diphosphoglycerate (2,3-DPG) which could probably due to electrolyte (salt) having an effect on the oxygen binding capacity to haemoglobin hyperglycaemic state itself, and also alter oxygen delivery since it causes an increase in the concentration of 2,3-DPG. However; this effect is balanced by an increase in a molecule with higher affinity for oxygen element. Chronic diabetes has effect on other blood indices like the white cell population and their functionality causing defective cell migration, phagocytosis, intracellular bactericidal activities and responses to mutagenic substances in diabetes subsequent to infection. Moreover, some of the haematological parameters could possibly vary due to the mode of therapies like diet, insulin therapy and oral medication [11]. Haematological parameters test can be performed by complete blood count (CBC). A complete blood count is a series...
Aim and objectives of the study

The collective aim of this study was to investigate the haematological parameters of chronic diabetes patients in some Rivers State Hospitals; however, the specific aims are as follows:

- To determine some haematological parameters of the affected subjects.
- To evaluate the effect of diabetes on haematological parameters of the affected subjects.

Materials and Methods

Port Harcourt is the capital and urban centre of Rivers state. It is the mainstay of all oil producing states in Niger Delta States and in Nigeria at large. It lies along the Bonny River and is located in the South-South geopolitical zone in Nigeria within Niger Delta region. Port Harcourt has a population of 1,382,592 from the report of the 2006 national population census. Though there seems to be an exponential population increase due to its location as the commercial nerve Centre, the foremost industrial city of the former eastern region of Nigeria and its importance as the centre of social and economic life of Rivers State cum Nigeria. From an area of 15.54km2 in 1914, Port Harcourt grew irresponsibly to an area of 360km2 in the 1980s. The coordinates are: 4°47'24"N, 6°59'36"E (Latitude: 4.772152; Longitude: 6.994514) and time zone is WAT (UTC+1). The city topographies are tropical monsoon climate with lengthy and heavy rains and very short dry season across the year. Occupation of the populace is fishing, crop farming etc. The city been a foremost industrial focal point has a large number of multi-national firms as well as other industrial activities, particularly business related to the petroleum industry (oil and gas). Port Harcourt city has two main oil refineries that process large quantities of crude oil over two hundred thousand barrels daily [14]. The study had its tenet within the two local government areas (Port Harcourt and Obio-Akpor) of the urban area of Rivers state.

Experimental Design

Laboratory investigation involved sample collection of venous blood sample into fluoride oxallate anticoagulant (32g/l) and EDTA container for glucose estimation and full blood count respectively. For glucose estimations, the fasting blood sample was analyzed using glucose oxidase method (enzymatic) with Select rAProS fully automated chemistry analyser (Poland). Full blood count was analyzed using Erma 210-PCE automated haematology analyzer (Japan).

The study adopted the cross-sectional designs using descriptive approach. Quantitative method was instrumental in the investigation of the effect of chronic diabetes on haematological parameters. The use of different data sources (primary and secondary) and research triangulation was employed to evaluate and elucidate the same evidence thereby, minimizing the impact of bias and increasing the plausibility and validity of the study in an attempt to map out and explain result fully from various standpoints by taking the strength of each while reducing the weaknesses of the individual critical outcome. For this study, a two stage sampling procedure was adopted. It started with the purposive selection of the Health care facilities within Rivers State urban city (convenience sampling); convenience because of the hard to reach diabetic patients as most facilities could not provide good number of
Results

The study investigated the effect of diabetes on the haematological parameters. The tests that were carried out include the determination of Total Red Cell Count, Haemoglobin estimation (Hb), Packed Cell Volume (PCV), Total White Cell Count, Differential leucocytes count and Platelet Count respectively.

A total of one hundred participants were recruited into the study in an equal distribution into each stratum of controls and diabetic patients. These participants further pass through a gender based categorization into male and female in a disproportionate manner comprising of twenty (20) males and thirty (30) females for each group giving a male to female ratio of 2.3. Furthermore, the result from this study shows the age and sex distribution of all participants. Participants were aged between 30 and 60 years. Females constituted 60% while males constituted 40%. There were 60 females and 40 males. However, this gives the percentage distribution between male and females diabetic and control subjects. The diabetic subjects studied were between the ages of 30-60 years. The control subjects were also similar in age and sex distribution Table 1.

Table 1: Percentage distribution of Age and Sex of the diabetic and Control subjects

<table>
<thead>
<tr>
<th>Age Group(Years)</th>
<th>Diabetic (N=50)</th>
<th>Control (N=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male (N=20)</td>
<td>Female (N=30)</td>
</tr>
<tr>
<td>31-40</td>
<td>3 (15%)</td>
<td>5 (16.7%)</td>
</tr>
<tr>
<td>41-50</td>
<td>5 (25%)</td>
<td>9 (30%)</td>
</tr>
<tr>
<td>51-60</td>
<td>12 (60%)</td>
<td>16 (53.3%)</td>
</tr>
</tbody>
</table>

Table 2: Mean, Standard Deviation and independent t-test Distribution of Diabetics and Controls.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Diabetic Subjects (N=50)</th>
<th>Control Subjects (N=50)</th>
<th>t - value</th>
<th>DF</th>
<th>P - Value</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hb (g/dl)</td>
<td>11.94 ± 1.84</td>
<td>14.32 ± 2.10</td>
<td>06.03</td>
<td>98</td>
<td>P&lt;0.05</td>
<td>Sig</td>
</tr>
<tr>
<td>RBC (x10^6)</td>
<td>3.60 ± 0.91</td>
<td>5.54 ± 0.86</td>
<td>10.96</td>
<td>98</td>
<td>P&lt;0.05</td>
<td>Sig</td>
</tr>
<tr>
<td>WBC (x10^9)</td>
<td>5.45 ± 0.36</td>
<td>4.31 ± 0.21</td>
<td>19.34</td>
<td>98</td>
<td>P&lt;0.05</td>
<td>Sig</td>
</tr>
<tr>
<td>PLT (x10^9)</td>
<td>377 ± 18</td>
<td>205.8 ± 8.9</td>
<td>60.29</td>
<td>98</td>
<td>P&lt;0.05</td>
<td>Sig</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>30.80 ± 3.26</td>
<td>40.25 ± 3.56</td>
<td>13.84</td>
<td>98</td>
<td>P&lt;0.05</td>
<td>Sig</td>
</tr>
</tbody>
</table>

Key: Hb=Haemoglobin, RBC=Red Blood Cell, WBC=White Blood Cell, PLT=Platelet, PCV=Packed Cell Volume NS=No Significant, Sig= Significant

The result obtained from the diabetic haematological parameters showed mean values of 11.94±1.84g/dl, 3.60±0.91x10^6/L, 5.45±0.36x10^6/L, 377±18x10^9/L, 377±18x10^9/L and 30.80±3.26% for Hb, RBC, WBC, PLT and PCV.
respectively. Comparatively, the control group had 14.32±2.10g/dl, 5.54±0.86 10^12/L, 4.31±0.21x10^9/L, 205.8±8.9x10^9/L and 40.25±3.56x10^9/L for Hb, RBC, WBC, PLT and PCV indices accordingly. The results of the independent t-test showed marked variation with a statistically significant mean difference (p<0.05) for all the haematological indices evaluated in this study (Table 2), (Figure 1). Relatively, evaluation of the haematological parameters within group specifically the diabetic group for male and female showed disparities (p<0.05) for WBC and PLT only; whereas, other haematological indices showed no significant differences as shown on Table 3.

![Figure 1: Mean Distribution of Haematological Parameters of Diabetic and Control.](image)

**Table 3: Showing t-tests of Diabetic Male and Diabetic Female Haematological Parameters.**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Diabetic Male (N=20)</th>
<th>Diabetic Female (N=30)</th>
<th>t - value</th>
<th>DF</th>
<th>P - Value</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hb (g/dl)</td>
<td>12.43 ± 1.57</td>
<td>11.45 ± 2.10</td>
<td>1.78</td>
<td>48</td>
<td>P&gt;0.05</td>
<td>N/S</td>
</tr>
<tr>
<td>RBC (x10^12)</td>
<td>3.66 ± 0.96</td>
<td>3.54 ± 0.86</td>
<td>0.46</td>
<td>48</td>
<td>P&gt;0.05</td>
<td>N/S</td>
</tr>
<tr>
<td>WBC (x10^9)</td>
<td>8.31 ± 0.21</td>
<td>8.59 ± 0.51</td>
<td>2.69</td>
<td>48</td>
<td>P&lt;0.05</td>
<td>Sig</td>
</tr>
<tr>
<td>PLT (x 10^9)</td>
<td>389 ± 20</td>
<td>365 ± 15</td>
<td>4.85</td>
<td>48</td>
<td>P&lt;0.05</td>
<td>Sig</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>31.36 ± 2.96</td>
<td>30.25 ± 3.56</td>
<td>1.15</td>
<td>48</td>
<td>P&gt;0.05</td>
<td>N/S</td>
</tr>
</tbody>
</table>


**Discussion**

Based on the pragmatic evidence bases research outcome established in this study, anaemia is one of the obvious defects that could possibly be induced by chronic diabetes as reported in this present study; red cell and its indices including haemoglobin concentration and reticulocyte counts were markedly reduced among the diabetic patients when matched side by side with the control group. The finding from this study which has been able to correlate diabetes with the likely risk of anaemia share similarity with previous studies [16-19] that reported the incidence of diabetic anaemia. In the same way, [17-19] in their previous separate studies supported evidence of anaemia in diabetes [18-20]. In addition, a prior comparative study by Ruchi & Pradeep [20] the haematological indices of diabetic subjects were decreased compared to the control subjects although, the study was decreased to type 1 diabetes (Figure 2) [21].

![Figure 2: Mean Distribution of Diabetic Male and Diabetic Female Haematological Parameters.](image)

Anaemia and its rising colossal consequences is a Public Health issue as it is one of the causes of high morbidity and mortality in any given population, and it serves as one of the Public Health indicators used in measuring the health status of an individual particularly in children and pregnant women, as well as those individual with special ailment like diabetes. In the time past, pregnant women and children to a great extent have been the target and lots of studies have been carried out and recommendations on how to reduce the high prevalence of anaemia in this vulnerable groups, but of late it is becoming paramount and critical to consider anaemia in other groups and among people with particular diseases like geriatrics, diabetes and nephropathy etc. Diabetes been a disease with no known cure for now; have been implicated to cause and make its victim at risk of developing anaemia as obtained in this study thus, there is need to focus on how to curb diabetic anaemia, thus incorporating it as part of the management/therapeutic strategy for a better outcome because diabetes is a global Public Health issues that cut across the socio-economic classes of high/middle/low, sex (male and female) and age (juvenile and elderly). In view of this, it calls for an urgent attention as the hyperglycaemic mounts tension on the blood parameters which in-turn alters the blood indices on prolonged exposure, and these chronic effects of high blood sugar or adverse effects of its treatment process (diabetic medications) could possibly have its consequences on the haematological parameters causing anaemia if it is not diagnosed and managed in good time [22].

Red cell count, packed cell volume (haematocrit) and haemoglobin were used in this study as a marker for anaemia and the concentrations of these anaemic markers have shown a relationship with diabetes mellitus as asserted by some scholars [23-28].

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Packed cell volume which is typically known as the blood level was reported to be correlated with high level of blood insulin; moreover, it is known that packed cell volume is determinant factor of blood viscosity [23-28]. A study done in the 1980s showed that higher blood level which is basically seen as high haematocrit level infer higher blood viscosity; this might predispose to insulin resistance and diabetes by limiting delivery of glucose, insulin and oxygen to metabolically active tissues though this was reported in type-2 diabetes [29]. This literally agrees with earlier studies which have found that haematological parameters play an important role in insulin resistance according to researches done in China by Wang et al. [29] and Korean based study by Choi et al. [30,31]. Besides, the underlying principle and mode of action by which haematocrit could possibly influence glucose metabolic activity is though not entirely and clearly understood, specifically with regards to its pathophysiology however, Hilsted & Christensen [31] reported dual effects of insulin on plasma volume and trans-capillary albumin mobility stating an inverse relationship between trans-capillary movement of albumin and plasma volume, due to insulin which will in-turn affect the blood volume [32]. Moreover, the quest to understand the cause and incidence of diabetic anaemia kept researchers studying and making findings so as to appreciate further the occurrence of anaemia in diabetes, this lead to two different studies which attributed its cause to a non-enzymatic glycosylation of erythrocyte membrane proteins as such, high blood glucose is associated with has a direct relationship with non-enzymatic glycosylation of erythrocyte membrane protein (Figure 3) [16,17].

Furthermore, two other studies showed a relationship between haemoglobin level and metabolic syndrome [33,34] and diabetes is one of the metabolic disease characterized with metabolic derangement of glucose impairment. Haemoglobin is one of the indices and significant markers of anaemia and its role cannot be undermined; it has a modulatory role in which case, it modulates bioavailability of nitric oxide thereby regulating endothelial activity [35]. Also, Haemoglobin concentration can be correlated with sCD40L level, one of the pro-inflammatory markers released by activated platelets, which predicts cardiovascular events in patients with high-risk atherosclerotic lesions and is increased diabetes as accounted by some studies [36-38].

Anaemia as a disorder seen in diabetes; so, diabetic anaemia could be seen as a co-morbidity which increases the populace disease burden, this is exemplified in anaemia in diabetic nephropathy. Some studies have reported anaemia in diabetic nephropathy as seen in streptozotocin induced diabetic rats according to [16] nonetheless; it was an animal based study. Other studies have as well shown that anaemia in diabetes is a predictive haematological tool seen in diabetic complications like renal dysfunction, cardiovascular disease etc. Diabetic anaemia as seen in the case of co-morbidity could further be attributed to a mal-function in the compensatory mechanism in the erythropoietic process in which case the renal organ (kidney) fail to respond to decreased haemoglobin level, due to inadequate production of erythropoietin. Furthermore, Hadjadj and colleagues [38] in their study “Erythropoietin-dependent anaemia: a possible complication of diabetic neuropathy” have opined that erythropoietin-deficiency diabetic anaemia could be effectively be corrected with the use of recombinant human erythropoietin [39].

In addition, the white cell population is a useful predictive tool; white blood cell is a biological inflammatory marker though non-specific marker. Diabetes is a condition characterized with inflammation and chronic inflammation is involved in the pathogenesis process and data from epidemiological studies suggests a relationship between total white blood cell count and the risk of developing diabetes [40]. Results obtained from this study showed an increased WBC in hyperglycaemic state (diabetes) as this present study reported an increase in the WBC count of the diabetic patients when compared to the control subjects. This finding is in accordance with prior studies suggestive of a relationship between WBC count and diabetes [19,41-44]. WBC count is a marker of systemic inflammation and might likely be involved in the pathophysiology of prediabetic states and subsequently in the manifestation of diabetes [41,42].

From the last objective “ascertaining the sex disparity in some of the haematological parameters among the diabetic subjects” comparatively, it was reported that diabetic females had higher white cell count than diabetic males on the other hand, diabetic males had a considerable difference in the platelet counts which vary from the result of the female diabetic patients. Whereas, the other haematological parameters evaluated in this study did not show discrepancy in the male female results meaning there was no gender specific particularities observed in reticuloctyes, haemoglobin and packed cell volume of the diabetic subjects.

Platelet count was increased in diabetic patients when compared with control subjects. This is in line with other studies. Nonetheless, a Turkish based cohort study in 2009 reported predictors of amputation in diabetic foot ulcer due to low haemoglobin concentration, high leukocyte count, elevated
erythrocyte sedimentation rate, increased platelet counts and other acute phase reactants. Similarly, Dalla & Faglia [17] shared same view in their study on overview of treatment strategies for diabetic foot ulcer [18,20]. Thrombocytosis (high platelet) as reported in this study is one of the consequences of diabetes; however, diabetes mellitus have a high risk of atherothrombotic health outcome. Other abnormalities like thrombosis which is common in thrombocytosis have placed diabetic patients at high risk of atherothrombosis, which causes occlusion of blood vessels as well as contributes to initiation and progression of both microvascular and macrovascular complications [14].

Conclusion

In the present study, a statistical significant difference exists between the haematological parameters of the diabetic patients and the control. Also, a gender cantered analysis showed an indication of statistical significant difference in diabetic white cell count and platelet counts only. Furthermore, the findings from this study showed anaemia, leucocytosis and thrombocytosis for the diabetic subjects as opposed to their control counterparts. It is therefore, an important observation that the development of anaemia in diabetes may predict many possible abnormalities in renal function. Furthermore, understanding the mechanism by which this occurs may provide the opportunity to develop therapeutic options that may improve patient outcome and curb the Public Health threat of increasing incidence of co-morbidity especially in our remote communities. The findings in the present study have implications for diabetic patients, thus it strongly suggested the need for routine full blood counts option in the diagnosis and management of chronic diabetes. Therefore, it is firmly recommended that diagnostic laboratories and clinicians should include full blood count as one of the routine critical laboratory tests required in the management and monitoring of diabetic patients and the treatment of diabetes should target at maintaining an optimal haematocrit in order to prevent other disease risk factors like nephropathy and cardiovascular disease etc.

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References


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