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Research Article

Serum and Urine Galectin-3 as a Diabetic Nephropathy Predictive Biomarker

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Abstract:

Background: Diabetic nephropathy (DN) is a major cause of end-stage kidney impairment in patients with type 2 diabetes mellitus (DM). Galectin-3 has been linked to the development of numerous pathological conditions. There is currently little information about the interaction between DN and galectin-3.

Objectives: The use of serum and urine galectin-3 as a unique forecasting diagnostic in DN patients.

Methods: The present study was conducted in Baquba Teaching Hospital, Specialized Consultation clinic, Internal Medicine Department and Iraq Specialized Laboratory in Baquba, Diyala governorate between October 2021 and February 2022 on 150 individuals with type 2 diabetes. Individuals were divided into three groups: Fifty individuals with an albumin/creatinine ratio (ACR) of 30 mg/g (normoalbuminuria), 50 patients with an ACR of 30-300 mg/g (microalbuminuria), and 50 healthy individuals with an ACR of 30 mg/g (healthy control). All subjects were subjected to extensive clinical assessment and examination and laboratory investigations (HbA1c, serum creatinine, serum galectin-3 as well as ACR, which was calculated based on urine test).

Results: The mean concentrations of serum and urine galectin-3 levels were noticeably greater in those with microalbuminuria than normoalbuminuria, (11.2±3.61), (7.0±2.17) as compared to (9.0± 1.32) (7.6± 1.72) respectively. Serum Galectin-3 showed a high sensitivity (100%**)** and specificity (86%). Urine Galectin-3 sensitivity was (98%) and specificity (78%).

Conclusion: This study has shown that serum and urine galectin-3 are important predictors of DN development in people with type 2 diabetes.

Keywords: Galectin-3; microalbuminuria; Albumin/creatinine ratio; diabetic nephropathy; diabetes mellitus.

Introduction:

Type 2 Diabetes mellitus (T2DM) is a prevalent disorder; the prevalence of which is increasing globally (1). Diabetic nephropathy (DN) is one of the microvascular complications and is the leading cause of end-stage renal disease (ESRD) in diabetic patients (2). The morbidity and mortality of this chronic complication can be reduced by early detection and proper management (3). In accordance with the American Diabetes Association's 2019 monitoring guidelines for diabetics with chronic kidney disease (CKD), urine albumin must be assessed (all individuals with T2DM should have a spot test for urine albumin/creatinine ratio and an estimated glomerular filtration rate (eGFR) performed at least once a year, as well as patients with concurrent hypertension, and those with T1DM for a period of five years (4). Although microalbuminuria can predict progression to overt nephropathy and end-stage renal disease, it has various restrictions for diabetic individuals. DN may still be clinically undetectable at this point, and urinary albumin excretion may continue to be normal. Furthermore, some patients with microalbuminuria will not experience or develop nephropathy (5-8). The 2012 KDIGO Convention covered a wide range of subjects concerning the care of patients with DM and CKD, including eGFR and urinary albumin/creatinine ratio (ACR) and CKD screening tests. For identifying individuals who are at risk of developing DN, ACR is suggested to be the most sensitive and accurate biomarker (9). A multifunctional lectin with a molecular weight between 32 and 35 KD is called galectin-3, which is found both inside and outside the cell. Extracellular galectin-3 interacts with the galactoside residues of extracellular matrix and cell surface glycoproteins through its C-terminal carbohydrate-recognition domain. Additionally, the N-terminus domain of intracellular galectin-3 mediates interactions between peptides. Galectin-3 can perform a number of tasks, including angiogenesis, integrin, growth, differentiation, apoptosis, and integrins, thanks to its structure and

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localization characteristics (10-14). Recently, it has also been discovered that galectin-3 is crucial for the onset and progression of a number of clinical conditions, including tissue fibrosis, immunological response, inflammation, and carcinogenesis (15-17). The role of galectin-3 in renal disease is complex and ambiguous. Research has connected renal fibrosis to galectin-3 is a multifunctional lectin with a molecular weight between 32 and higher (18). However, multiple experimental studies (AGEs) suggest that galectin-3 may be a useful receptor for the clearance of advanced glycation products (19-20).

Aim of the study: The use of serum and urine galectin-3 as a unique forecasting diagnostic in DN patients

Patients and Methods:

This case-control study was carried out between October 2021 and February 2022, in which 150 diabetic patients were enrolled. The study was carried out in Baquba Teaching Hospital/ Specialized Consultation clinic/ Internal Medicine Department and the Iraq Specialized Laboratory in Baquba, Diyala. The study was approved by the Baghdad University College of Medicine, ethical committee. Each participant provided informed consent. The cases were divided into three groups, 50 individuals each, as follows: Group 1: Fifty diabetics with normal albuminuria (28% males, 72% females), Group 2: Fifty diabetics with microalbuminuria (48% males, 52% females), and Group 3: Fifty healthy controls (36% males, 64% females). The exclusion criteria included patients with T1DM, T2DM with macroalbuminuria, pregnancy, obesity, smoking, any acute or chronic inflammatory illness, malignancies, endocrine diseases, and autoimmune conditions. After ruling out other potential sources of proteinuria, serum creatinine, and ACR were used to identify DN in individuals with T2DM.

Blood and urine collection and laboratory assay: All subjects had their fasting blood and urine samples taken in the morning. The urine and serum were separated and refrigerated at -80°C. Laboratory measurements of serum glucose, HbA1c, urea, and serum creatinine concentrations as well as sandwich enzyme-linked immunosorbent assay measurements of serum and urine Galectin-3 levels were done (Human reader HR).

Results:

Table 1 shows the demographic characteristics and laboratory findings of the three study groups. All study groups were matching regarding age, sex, BMI, duration of T2DM, serum urea, and creatinine. Other variable like random blood glucose (RBG), HbA1c, urinary creatinine, urinary albumin, ACR were significantly different in diabetic patient with microalbuminuria compared to healthy controls and not significantly different in diabetics with normal albuminuria compared to healthy controls. There was no significant difference regarding body mass index BMI, (RBG), serum urea between diabetic patients with normal albuminuria and diabetic patients with microalbuminuria. The duration of T2DM was significantly different in diabetics with microalbuminuria compared to those with normoalbuminuria. All parameters included in renal function tests (urea, creatinine, albumin and ACR) were higher in diabetics with microalbuminuria than those without, with highly significant differences. ACR was not significantly higher in diabetics with microalbuminuria compared to those without. In comparison to diabetics without microalbuminuria and to controls compared to diabetics with microalbuminuria, serum creatinine was considerably greater in diabetics with microalbuminuria. There were no significant differences between the control and the diabetics with normoalbuminuria in terms of serum creatinine, while a significant difference was found between the controls and the diabetics with microalbuminuria.

Table 1: Demographic and laboratory variables for the three study groups

Parameter		Control (n= 50)	Microalbuminuria (n= 50)	Normoalbuminuria (n= 50)	*P*-value[1]	P-value[2]	P-value[3]
Age (years)*		48.5±12.00	59.0±12.75	54.5±8.00	<0.001		
Gender (N)†	M	18	24	14	0.224	0.391	0.039
	F	32	26	36			
Duration of disease		/	9.4 ± 3.49	6.0 ± 2.33	/	/	<0.001
BMI (kg/m^2)		27.5±4.46	30.2±5.68	30.8±4.29	0.012	<0.001	0.520
RBG (mg/dl)		107.1±14.16	311.3±103.2	255.2±82.41	<0.001	<0.001	0.003
HbA_{1c} (%)		4.9±0.62	11.2±1.60	9.1±1.40	<0.001	<0.001	<0.001
S. urea (mg/dl)		29.6±7.24	39.8±7.85	32.8±8.00	<0.001	<0.001	0.039
S. creatinine (mg/dl)		0.7±0.19	0.9±0.20	0.7±0.14	<0.001	0.765	<0.001
U. creatinine (mg/dl)		112.9±46.46	50.2±30.88	85.2±50.58	<0.001	0.005	<0.001
U. albumin (mg/dl)		1.6±0.49	3.9±4.49	1.5±0.71	<0.001	0.254	<0.001
Alb/Cr ratio		15.2±18.67	86.4±55.78	18.7±6.45	<0.001	0.222	<0.001

P-value[1] for the relationship between controls and Microalbuminuria group; P-value[2] for the relationship between controls and Normoalbuminuria group; P-value[3] for the relationship between Microalbuminuria and Normoalbuminuria.

There was a high concentration of serum Galectin-3 in diabetics with microalbuminuria with a highly significant difference from those without microalbuminuria where Galectin-3 was lower. There was a significant difference in the mean serum Galectin-3 between the control group and the diabetics with normoalbuminuria. Similarly, there was a significant difference between controls and diabetics with microalbuminuria. There was a significant difference in serum Galectin-3 levels between diabetics without microalbuminuria and diabetics, table 2 and figure 1. Similarity, there was a significant difference in the mean urine Galectin-3 between controls and diabetics with normoalbuminuria. There was a significant difference between controls and diabetics with microalbuminuria. The variation was clear in urine Galectin-3 between diabetic without microalbuminuria and diabetic with microalbuminuria.

Table 2: Serum and urine Galectin-3 in diabetics and control

Galectin-3 (ng/ml)	Control (n= 50)	Microalbuminuria (n= 50)	Normoalbuminuria (n= 50)	P-value[1]	P-value[2]	P-value[3]
S. Galectin-3	4.1± 0.72	11.2± 3.61	7.0± 2.17	<0.001	<0.001	<0.001
U. Galectin-3	5.6± 1.35	9.0± 1.32	7.6± 1.72	<0.001	<0.001	<0.001

P-value[1]: Relationship between control and Microalbuminuria; P-value[2]: Relationship between control and Normoalbuminuria; P-value[3]: Relationship between Microalbuminuria and Normoalbuminuria.

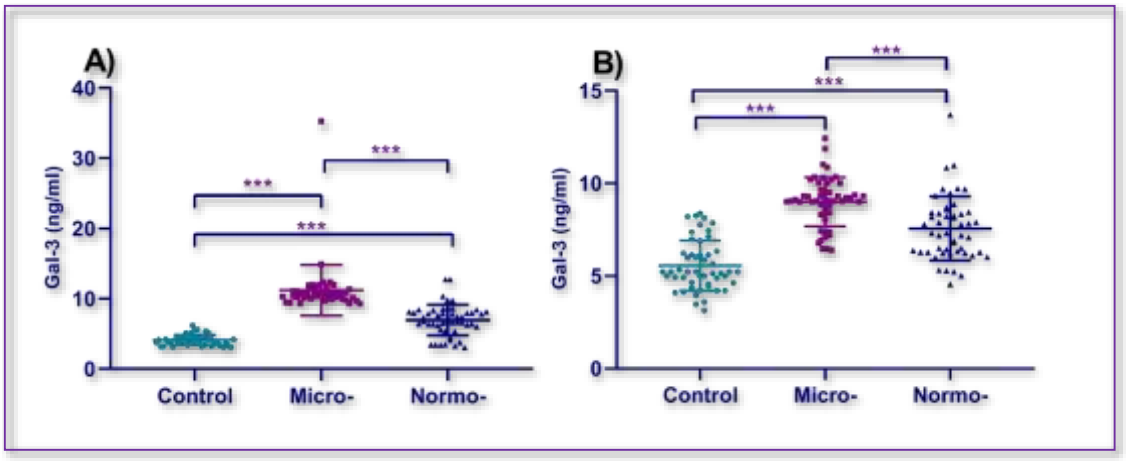

Figure 1: A) Serum Galectin -3 B) Urine Galectin-3 in the study groups.

The mean serum galectin-3 levels in diabetics with microalbumin was (11.2±3.61 ng/ml) which was much higher than that of patients without microalbuminuria (normoalbuminuria) (7.0±2.17 ng/ml) and both were higher than controls (4.1±0.72 ng/ml) with a highly significant difference. Likewise, patients with microalbumin showed higher urine galectin-3 concentration than patients without microalbuminuria (9.0±1.32 ng/ml versus 7.6±1.72) with a highly significant difference, Figure 2.

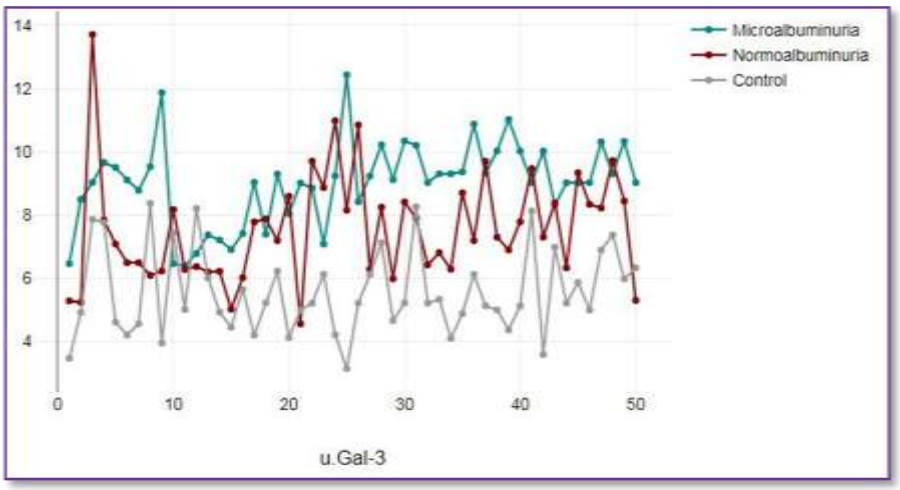

Figure 2: Concentration of urine Galectin -3 in three groups

Table 3 shows that S. galectin-3 parameters scored the highest sensitivity (100%), followed by Urinary galectin-3 (98%) with significant difference in screening diabetics with micro-albuminuria. As for specificity Serum galectin-3, and Urinary. galectin-3 scored a specificity of (86%, and 78%) respectively.

Table 3: ROC curve analysis for biochemical parameters in serum of diabetics with microalbuminuria and control subjects

Variable(s)	AUC	P Value	C.I. 95%		Cut off	Sensitivity %	Specificity %
			Lower	Upper			
S. Galectin-3 (ng/ml)	1.000	<0.001***	1.000	1.000	4.92	100%	86%
U. Galectin-3 (ng/ml)	0.961	<0.001***	0.930	.992	6.31	98%	78%

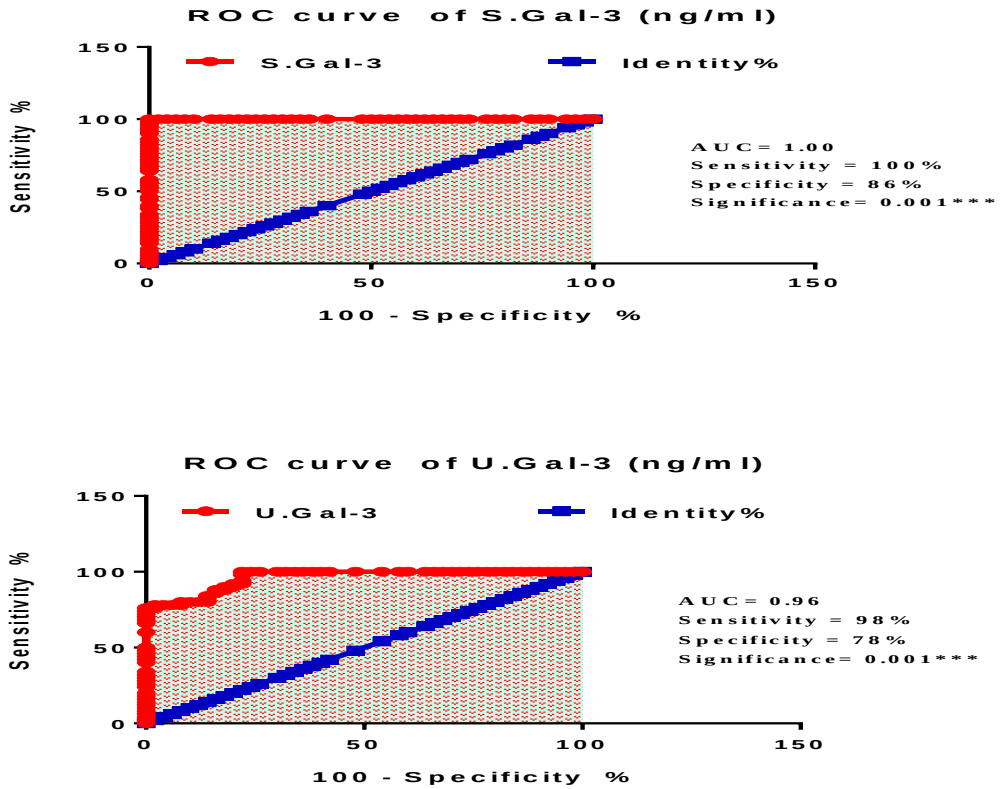

Figure 4: ROC curve analysis for Galectin-3 in three study groups

Table 4 and figure 5 show that Serum Galectin-3 and Urinary. Galectin-3 parameters scored highest sensitivity (86%, and 84%) respectively, with a significant difference in screening diabetics patients with normoalbuminuria. As for specificity of Urinary Galectin-3 scored high specificity (75%) compared to Serum Galectin-3 which scored low specificity (64%).

Table 4: ROC curve analysis for Galectin-3 in serum and urine of the study groups

Variable(s)	AUC	P Value	C.I. 95%		Cut off	Sensitivity %	Specificity %
			Lower	Upper			
Serum.Galectin-3 (ng/ml)	0.868	<0.001***	0.788	0.949	4.12	86%	52%
Urinary Galectin-3 (ng/ml)	0.838	<0.001***	0.761	0.915	6.12	84%	75%

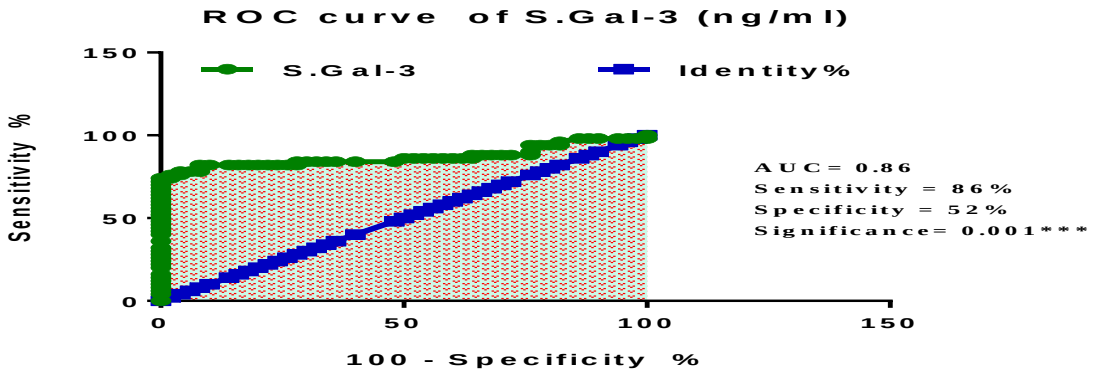

Figure 5: ROC curve analysis for biochemical parameters in the serum of the study groups

Discussion:

The role of Galectin-3 in the initiation and evolution of chronic kidney failure in diabetics has attracted a considerable amount of attention. Galectin-3 involvement in the causation of DN is still a subject of debate, and it is unclear how exactly high levels of the protein are reflected in the blood and urine in DN (21). The most notable finding of the current study is that patients with microalbuminuria had considerably greater mean levels of galectin-3 than those with normoalbuminuria, suggesting that circulating galectin-3 levels are a crucial factor in the onset and progression of DN. The present investigation confirms earlier studies linking elevated levels of galectin-3 to DN, which found that diabetics with microalbuminuria had considerably higher levels of galectin-3 than diabetics with normal albuminuria (22). The current study agrees with another study, which reported that patients with microalbuminuria had mean galectin-3 levels that were substantially greater than those with normoalbuminuria (23). Galectin-3 was also found to have the capacity to bind to advanced glycation end products (AGEs), both of which build up in the kidney. In microalbuminuria at cut-off value of 4.92 ng/mL, the sensitivity and specificity of serum galectin-3 in the patients who were investigated, galectin-3 was used as a predictive biomarker to identify kidney failure were 100% and 86%, sensitivity and specificity of urine galectin-3 as a predictive biomarker in the patients under study were 98% and 78%, respectively, at the cut-off value of 6.31 ng/ml. Serum galectin-3 is a promising biomarker for identifying diabetes, according to Yilmaz et al (24). A blood galectin-3 cut-off value of 4.12 ng/mL had a sensitivity of 86% and a specificity of 56% in ROC curve analysis in normal albuminuria. The urine galectin-3 sensitivity and specificity were 84% and 75%, respectively, at the cut-off level of 6.12 ng/mL

Limitation:

To determine if this association may be converted into therapeutic targets, additional functional studies will be required to examine the relationship between and the various phases of diabetic nephropathy in patients with type 2 diabetes mellitus. Evaluation of serum urine Gal-3 in a patient with or without diabetic nephropathy in GDM.

Considering that it can serve as a substitute biomarker for microalbumin. Therefore, with this knowledge, practitioners can anticipate who would develop nephropathy earlier and thereby enhance prevention of this fatal disease.

Conclusions:

Serum and urine galectin-3 seem to be important predictors of diabetic nephropathy development in people with type 2 diabetes mellitus.

Authors' Declarations:

We confirm that all figures and Tables in the manuscript are original to the current study. Besides, the Figures and images, which do not belong to the current study, have been given permission for re-publication attached to the manuscript. Authors sign on ethical considerations' Approval-Ethical Clearance: The project was approved by thedepartment of Biochemistry, Medical College, University of Baghdad,Medical City, Ministry of Healtand Informed consent was attained from each participant The samples collected and treated) according to the code number (34) on (2/ 9/2021).

Authors' Contributions:

Study conception & design: Prof. Dr. Manal K. Rasheed, Data acquisition: Dalia M. Saleh Prof. Dr. Manal K. Rasheed, and Ali R. Hameed: Data analysis & interpretation: Dalia M. Saleh Prof. Dr. Manal K. Rasheed, Manuscript preparation: (Dalia M. Saleh Prof. Dr. Manal K. Rasheed, Manuscript editing & review: Prof. Dr. Manal K. Rasheed,

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الكالكتين ـ٣ في المصل والادرار كمؤشر حيوي تنبؤي لاعتلال الكلية السكري

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الخلاصة:
خلفية البحث: إعتلال الكلية السكري هو أحد الأسباب الرئيسية لمرض الكلى في نهاية المرحلة في مرضى السكري من النوع الثاني. تم ربط الكالكتين -٣ بتطور العديد من الحالات المرضية. لا يوجد حاليا سوى القليل من المعلومات حول العلاقة بين الكالكتين -٣ وإعتلال الكلية السكري.
الهدف: إستخدام الكالكتين -٣ قي مصل الدم والبول كمؤشر بيولوجي تنبؤي فريد في مرضى إعتلال الكلية السكري
المنهجية: أجريت هذه الدراسة في مستشفى بعقوبة التعليمي والعيادة الإستشارية المتخصصة وقسم الطب الباطني ومختبر العراق التخصصي في بعقوبة/ ديالى بين تشرين الأول 2021 وشباط 2022 على 150 مريضا بالسكري من النوع الثاني. تم تقسيم المرضى إلى ثلاث مجموعات: المجموعة الأولى تضمنت 50 مريضا يعانون من نسبة الألبومين / الكرياتينين 30> مجم / جم (البيلة الألبومينية الطبيعية)، المجموعة الثانية تضمنت 50 مريضا يعانون من نسبة الألبومين / الكرياتينين ضمن 30-300 مجم / جم (البيلة الألبومينية الزهيدة)، والمجموعة الثالثة شملت 50 مريضا مع نسبة الألبومين / الكرياتينين 30> مجم / جم من الاصحاء). خضع جميع المرضى لما يلي: أخذ التاريخ الكامل، الفحص السريري، التقييم المخبري (الهيموغلوبين السكري، الكرياتينين، نسبة الألبومين / الكرياتينين، الكالكتين -3 في المصل والبول).
النتائج: كان متوسط تركيز الكالكتين-3 في المصل والبول أعلى بشكل ملحوظ لدى المصابين ببيلة ألبومينية دقيقة مقارنة بأولئك الذين لديهم بيلة ألبومينية طبيعية، (11.2±3.61)، (7.0±2.17) مقارنة بـ (9.0±1.32) (7.6±1.72) على التوالي. أظهر الكالكتين-3 في المصل حساسية عالية (100%) وخصوصية (86%). أما في البول، فقد بلغت حساسية الجالكتين-3 (98%) والخصوصية (78%).
الإستنتاج: يعتبر الكالكتين-3 في مصل الدم والبول مؤشرا هاما لتطور إعتلال الكلية السكري بين المرضى الذين يعانون من مرض السكري من النوع الثاني.
الكلمات المفتاحية: إعتلال الكلية السكري، كاالكتين -3، نسبة الألبومين / الكرياتينين، بيلة الألبومين، داء السكري