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Expression of galectin-1 and galectin-3 in renal cell carcinoma; immunohistochemical study

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ABSTRACT

Background and aims: Galectins comprise a large family of calcium independent lectins. Galectin-1 and galectin-3 contribute to neoplastic transformation, angiogenesis, and tumor metastasis in some cancers. This study aimed at studying the immunohistochemical expression of both galectin-1 and galectin-3 in renal cell carcinoma (RCC) variants and detecting the possible association of galectins with various clinicopathological parameters.

Materials and methods: Sections from 67 formalin-fixed paraffin-embedded tissue blocks of RCC variants were stained with galectin-1 and galectin-3. Expression was assessed in tumor tissue and adjacent renal parenchyma and was correlated with clinicopathological criteria.

Results: In apparently normal renal parenchyma adjacent to tumor tissue, galectin-1 was expressed in 27 (40.2%) of specimens in renal tubules and glomeruli, while 34 (50.7%) of specimens showed galectin-3 expression in renal tubules sparing glomeruli. In tumor tissue, galectin-1 showed high expression in 47 (70.1%) and low expression in 20 (29.9%) of specimens. Galectin-3 had high expression in 15 (22.4%) and low expression in 52 (77.6%) of specimens. Significant association was detected between expression of galectin-1 and galectin-3 and the type of RCC ($P = 0.032$) and ($P = 0.006$), respectively. Significant inverse association was detected between the expression of galectin-3 and the presence of tumor haemorrhage and necrosis ($P = 0.014$) and ($P = 0.039$), respectively.

Conclusion: Galectin-1 and galectin-3 are overexpressed in RCC with different percentage in different subtypes. Galactin-1expression is more in tumor tissue than surrounding renal parenchyma suggesting that it has a carcinogenic role. Galectin-1 and galectin-3 overexpression in chromophobe RCC suggests that they may have diagnostic role.

1. Introduction and aim of the work

Renal cell carcinoma (RCC) is among the top ten most common cancers worldwide [1]. It arises from the renal parenchyma and can be further specified into different histological subtypes. The most common subtypes include; clear cell RCC (CRCC) which represents (70%) of all RCC, followed by papillary RCC with an incidence ranging from (10% to 15%) and chromophobe RCC which represents (5%) [2].

The incidence of RCC varies internationally; the incidence in more developed regions is more than twice that of less developed regions [2]. Despite many advances in diagnosis and treatment, the prognosis for RCC remains poor, especially in advanced stages [3]. Therefore, identifying new biological markers that could determine the risk of poor prognosis is important designing treatment strategies in patients with RCC [4].

Tumor characteristics such as tumor stage and grade seem to have limited value in predicting the clinical outcome of individual patients. Moreover, different histological subtypes of RCC have distinct genetic and biologic features that determine clinical course and outcome [5]. Molecular profiling holds promise in this regard and could lead to a new era of personalized medicine in RCC [6].

Galectins comprise a large family of calcium independent lectins that are characterized by their affinity for β-galactoside derivatives by conserved sequence elements [7]. They are involved in a wide range of cellular processes including; growth, proliferation, differentiation, apoptosis, homeostasis, and vascular embryogenesis [8]. Several clinical evidences have shown that galectins contribute to neoplastic transformation, tumor cell survival, angiogenesis, and metastasis of

Abbreviations: RCC, renal cell carcinoma; CRCC, clear cell renal cell carcinoma; ISUP, International Society of Urological Pathology; LVI, lymphovascular infiltration

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tumor in different organs [7,8]. Galectin-1 and galectin-3 are two members of galectin family that are expressed by macrophages, epithelial cells, T cells, and fibroblasts [9].

Galectin-1 is encoded by the LGALS1 and is widely expressed by different tissues as natural killer cells and endothelial cells where it plays a key role in suppressing innate and adaptive immune responses. The presence of galectin-1 within the tumor microenvironment has been shown to contribute significantly to the establishment of local immune resistance through interactions with β-galactoside-expressing glycoproteins on the T cell surface [10]. Galectin-1 can interact intracellulary with different types of proteins and it is suggested to play a role in cancer pathogenesis through different pathways as immunosuppression, angiogenesis and metastasis [11].

The expression level of galectin-1 has been evaluated in various kinds of tumors, and an association between decreased galectin-1 expression level and tumor invasiveness and lymph node metastasis has been found in many tumors as bladder carcinoma and lung adenocarcinoma. However, upregulation of galectin-1 was found to correlate with poor prognosis in some other tumors like osteosarcoma and breast carcinomas [12].

Galectin-3 interacts with glycoprotein receptors on the cell membrane and controls several cellular functions. It has been reported to be involved in carcinogenesis and many cancer-related physiological and pathological functions, such as cell growth, cell adhesion, angiogenesis, and apoptosis [13]. Expression of galectin-3 was recently shown to correlate with the attenuation of drug induced apoptosis that contribute to cell survival, aggressiveness, and metastasis in cancer [14].

The aim of this study was to elucidate the expression of both galectin-1 and 3 in RCC subtypes as well as in the adjacent corresponding tumor free renal tissue and to determine the association between their expression and various clinicopathological prognostic parameters of patients with RCC in Upper Egypt.

2. Material and methods

2.1. Patients and materials

The study is descriptive-analytic study. It was conducted retrospectively on 67 formalin-fixed paraffin embedded tissue blocks of a spectrum of RCC. The blocks were obtained from the archive of the Surgical Pathology Laboratory, Assiut University Hospital, Faculty of Medicine, Assiut University. All specimens included in this study were non-selected consecutive series of RCC referred to the laboratory between years 2004 and 2015. The study was approved by Research and Ethical Committee at Faculty of Medicine, Assuit University. The available clinical features were retrieved from the hospital medical records, including patient age, gender, tumor site, laterality and tumor size (Table 1).

Hematoxylin and eosin stained sections of RCC were examined for detailed histopathologic features including histologic type (according to the World Health Organization histologic classification) [2], nuclear grade (International Society of Urological Pathology “ISUP” grading scheme: (grade 1 to grade 4)) [15], tumor stage (according to AJCC Cancer Staging Handbook of the American Joint Committee on Cancer) [16], presence or absence of tumor haemorrhage, tumor necrosis, lymphovascular infiltration (LVI), the host immune response and infiltration of the adjacent tissue (capsule, perinephric fat and renal sinus).

2.2. Immunohistochemistry

Immunohistochemical staining for the sections was performed using the avidin–biotin complex method. Tissue sections of 4 μm thickness were taken from tissue array blocks. Paraffin sections were de-waxed and then rehydrated through descending graded ethanol series down to distilled water. To block the endogenous peroxidase, the rehydrated sections were treated with 6% hydrogen peroxide for 10 min. For epitope retrieval, sections were microwaved in citrate buffer, pH 6 for a total 20 min. Non-specific staining had been blocked by superblock (UV block) for 10 min.

Sections were incubated with the primary antibodies for 60 min. The antibodies used were galectin-1 (Genemed, clone NBP2, CA, USA, diluted + at 1:400) and galectin-3 (Genemed, clone 9C4, CA, USA, diluted at 1:100).

Secondary staining kits were used according to the manufacturer's instructions (Thermo scientific corporation Fremont, CA, USA). Counter staining was done with Mayer's hematoxylin and sections then are examined by light microscopy. In each staining run, tissue specific positive control slides were included. As a positive control for galectin-1 immunostaining was performed on tissue sections of colonic adenocarcinoma and tissue sections of papillary thyroid carcinoma were used as positive control for galectin-3. Negative control slides were stained in parallel, by the omission of the primary antibodies.

Table 1
Clinicopathologicalparameters of studied cases (n = 67).

Factor	Number	Percentage
Total	67	100%
Age	25–75 years (mean, 53.2)	
Gender		
Male	42	62.7%
Female	25	37.3%
Size		
≤4 cm	11	16.4%
> 4 cm, ≤7 cm	23	34.3%
> 7 cm. ≤10 cm	18	26.9%
> 10 cm	15	22.4%
Histopathological type		
Clear cell RCC	35	52.2%
Clear cell RCC with sarcomatoid differentiation	8	11.9%
Papillary RCC typeI	9	13.4%
Papillary RCC type II	7	10.4%
Chromophobe type	8	11.9%
Site		
Upper pole	28	41.8%
Lower pole	19	28.4%
Mid pole	8	11.9%
Replacing most of kidney	12	17.9%
Laterality		
RT	32	47.8%
LT	35	52.2%
Bilateral	0	0%
Grade of clear cell RCCs		
1	10	14.9%
2	20	29.9%
3	9	13.4%
4	4	6%
LN metastasis		
Positive	5	7.5%
Negative	3	4.5%
Unreported	59	88.1%

2.3. Evaluation of galectin-1 and galectin-3 expression

Galectin-1 and galectin-3 were assessed and the reactivity for them was defined as homogenously brown cytoplasmic staining. Cases were classified into two groups; low galectins expression (< 50% of tumor cells show galectins positivity) and high galectins expression (50% and more of tumor cells are positive for galectins) [8,17]. Accordingly, tissue specimens are divided into two categories; negative that show low galectins expression and positive if the expression of galectins is high.

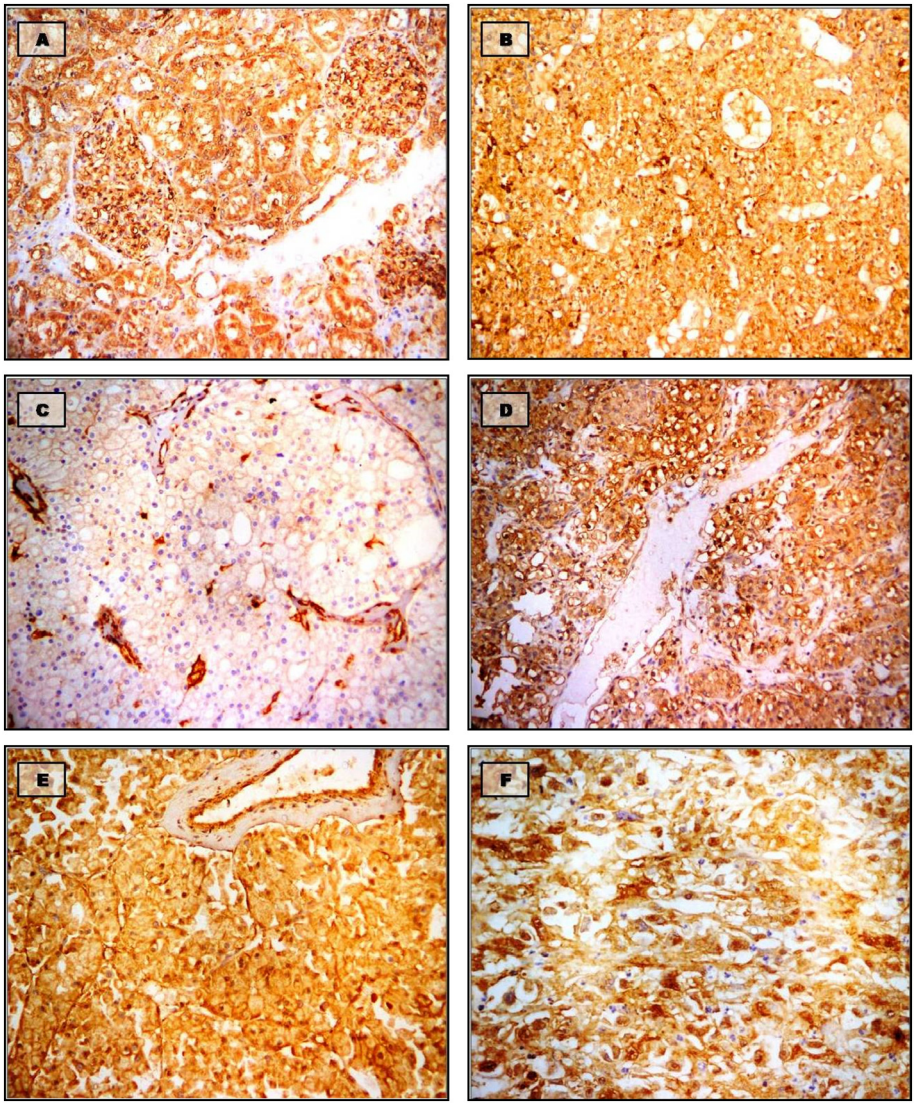

Fig. 1. Immunohistochemical expression of galectin-1 showing positive staining in renal tubules and glomeruli of apparently normal renal tissue adjacent to RCC (A). High expression of galectin-1 (> 50% of tumor cells) in CRCC (B), papillary RCC (D), chromophobe RCC (E) and sarcomatoid RCC (F). Negative staining in other case of CRCC (C). (×200).

2.4. Statistical analysis

Chi squared test was used for assessment of association between expression of galectin-1, galectin-3 and different clinicopathological criteria of tumors, using $P < 0.05$ as the cutoff.

3. Results

3.1. Clinicopathological characteristics

The patients' clinicopathological characteristics are summarized in (Table 1). Briefly, the 67 evaluated cases of renal neoplasms included 43 CRCC; 8 cases of them showed sarcomatoid differentiation, 16 papillary RCC; 9 of them were type I and 7 were type II and 8 chromophobe RCC. Of the 43 CRCC, according to the ISUP grading scheme, nuclear grade distribution was as follows: 10 cases were grade 1 (14.9%); 20 cases were grade 2 (29.9%), 9 cases were grade 3 (13.4%), and 4 cases were grade 4 (6%).

3.2. Expression of galectin-1 and galectin-3

In adjacent corresponding tumor free renal tissue; galectin-1 was positively expressed in 27 (40.2%) of specimens within the distal, proximal tubules and the glomeruli (Fig. 1A). Galectin-3 protein was positively expressed in 34 (50.7%) of specimens within the distal and proximal tubules. However, the glomeruli do not show any staining (Fig. 2A).

In tumor tissue, galectin-1 showed high expression in 47 (70.1%) of specimens and low expression in 20 (29.9%) of specimens (Fig. 1B, F) while galectin-3 showed high expression in 15 (22.4%) of specimens and low expression in 52 (77.6%) of specimens (Fig. 2B, F).

The expression of galectin-1 was significantly higher in RCC tissue compared to adjacent free kidney tissue. Regarding galectin-3, it was significantly more expressed in the microscopically free renal tissue than the nearby RCC.

3.3. Association between expression of galectin-1 and clinicopathological criteria

Significant association was detected between high expression of

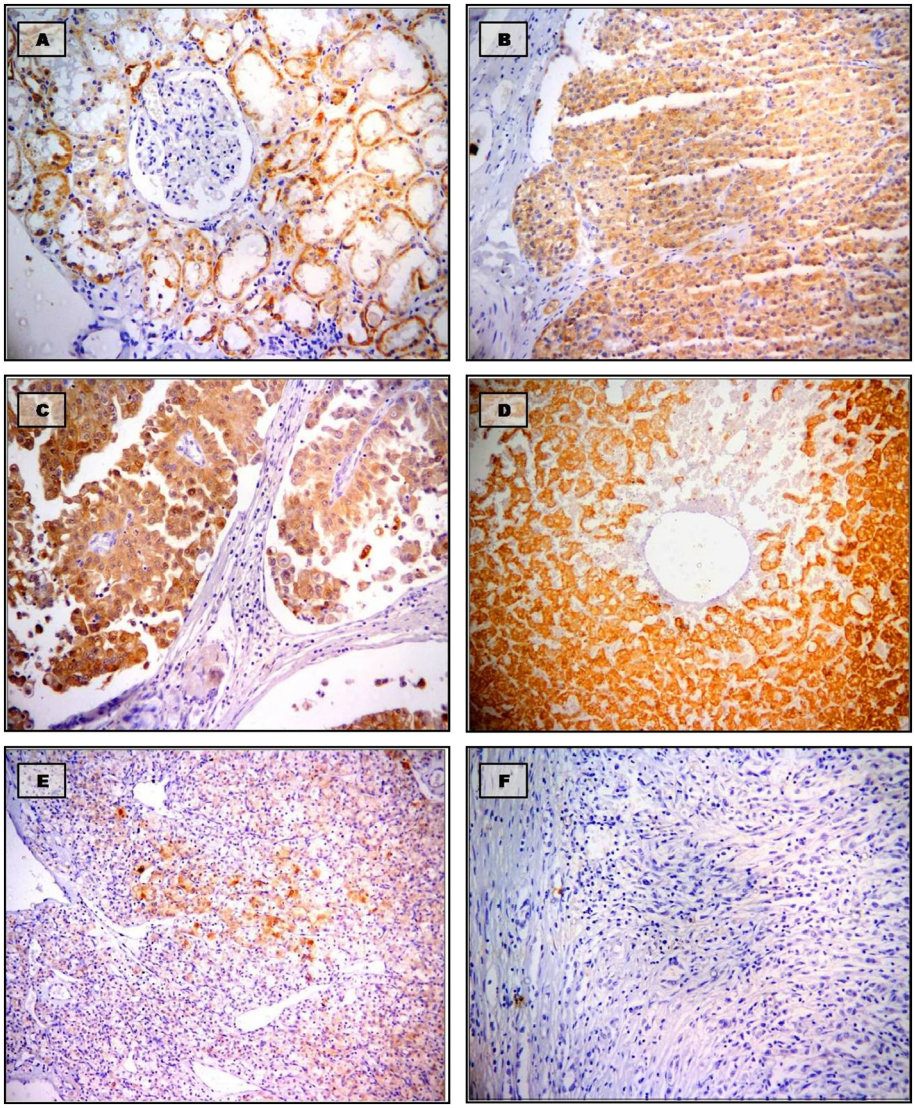

Fig. 2. Immunohistochemical expression of galectin-3 showing positive staining in renal tubules and sparing the glomeruli of apparently normal renal tissue adjacent to RCC (A). High expression of galectin-3 (> 50% of tumor cells) in CRCC (B), papillary RCC (C), chromophobe RCC (D). A case of CRCC showing focal positivity of galectin-3 (E). Absence of staining of galectin-3 in sarcomatoid RCC (F). (×200).

galectin-1 and the histopathologic subtypes of the tumors (P = 0.032) with 51.1% of CRCC and 100% of chromophobe RCC showed high expression of galectin-1 (Table 2).

Significant association was also detected between the high expression of galectin-1 and tumor site (P = 0.023). In this regard, about 51.1% of tumors with high galectin-1 expression were located in the upper pole compared to 23.4%, 6.4% and 19.1% of tumors located in lower pole, mid zone or replacing most of kidney, respectively (Table 2).

No significant association was detected between high expression of galectin-1 and the patient age (P = 0.228), sex (P = 0.174), tumor size (P = 0.828), laterality of tumors (P = 0.768), tumor stage (P = 0.680), ISUP grading nuclear grade of clear cell RCC (P = 0.092), presence of LVI (P = 0.076) or the presence of host immune response (P = 0.461). Also the presence of tumor necrosis, haemorrhage, capsular infiltrate, perinephric fat infiltrate or sinus infiltrate did not show significant association with high expression of galectin-1 with P value equal 0.469, 0.443, 0.207, 0.906, and 0.114, respectively.

3.4. Association between expression of galectin-3 and clinicopathological criteria

Significant association was detected between the expression of galectin-3 and the histopathologic types of tumors (P = 0.006) with 78% of CRCC and 94.4% of papillary RCC showed low expression, while 62.5% of chromophobe RCC showed high expression of galectin-3 (Table 3).

Significant inverse association was detected between the expression of galectin-3 and presence of tumor haemorrahge and necrosis (P = 0.014) and (P = 0.039), respectively. In about 70% of cases that showed presence of haemorrahge and 89.7% of cases that showed presence of necrosis, galectin-3 expression was low (Table 3).

No significant association was detected between high expression of galectin-3 (≥50%) and the patient age (P = 0.226), sex (P = 0.145), tumor size (P = 0.559), laterality of tumors (P = 0.204), tumor site (0.566), tumor stage (P = 0.776), ISUP nuclear grade of CRCC (P = 0.459), presence of LVI (P = 0.273) or the presence of host-immune response (P = 0.855). Also the presence of tumor capsular infiltrate, perinephric fat infiltrate or sinus infiltrate did not show significant association with high expression of galectin-3 with P value

Table 2
Association of galectin-1 and clinicopathological parameters.

Clinicopathological factors	≥50% expression of galectin-1	< 50% expression of galectin-1	Total	P value
Age				
< 51 years (median)	24 (77.4%)	7 (22.6%)	31	0.228
≥51 years (median)	23 (63.9%)	13 (36.1%)	36	
Gender				
Male	27 (64.3%)	15 (35.7%)	42	0.174
Female	20 (80%)	5 (20%)	25	
Size				
≤4 cm	8 (72.7%)	3 (27.3%)	11	0.828
> 4 cm, ≤7 cm	15 (65.2%)	8 (34.8%)	23	
> 7 cm. ≤10 cm	14 (77.8%)	4 (22.2%)	18	
> 10 cm	10 (66.7%)	5 (33.3%)	15	
Laterality				
RT	23 (71.9%)	9 (28.1%)	32	0.768
LT	24 (68.6%)	11 (31.4%)	35	
Bilateral	0 (0%)	0 (0%)	0	
Site				
Upper pole	24 (85.7%)	4 (14.3%)	28	0.032
Lower pole	11 (57.9%)	8 (42.1%)	19	
Mid pole	3 (37.5%)	5 (62.5%)	8	
Replacing most of kidney	9 (75%)	3 (25%)	12	
Histological type				
Clear type RCC	24 (58.5%)	17 (41.5%)	41	0.023
Papillary type RCC	15 (83.3%)	3 (16.7%)	18	
Chromophobe RCC	8 (100%)	0 (0%)	8	
Nuclear grade of clear RCC				
1	9 (90%)	1 (10%)	10	0.092
2	10 (52.6%)	9 (47.4%)	19	
3	4 (50%)	4 (50%)	8	
4	1 (25%)	3 (75%)	4	
Capsular infiltration				
Present	18 (62.1%)	11 (37.9%)	29	0.207
Absent	29 (76.3%)	9 (23.7%)	38	
Perinephric fat infiltrate				
Present	10 (71.4%)	4 (28.6%)	14	0.906
Absent	37 (69.8%)	16 (30.2%)	53	
Sinus infiltrate				
Present	10 (55.6%)	8 (44.4%)	18	0.114
Absent	37 (75.5%)	12 (24.5%)	49	
Tumor stage (pT)				
T1	21 (67.7%)	10 (32.3%)	31	0.680
T2	15 (68.2%)	7 (31.8%)	22	
T3	10 (83.3%)	2 (16.7%)	12	
T4	1 (50%)	1 (50%)	2	
Tumor haemorrhage				
Present	37 (72.5%)	14 (27.5%)	51	0.443
Absent	10 (62.5%)	6 (37.5%)	16	
Tumor necrosis				
Present	19 (65.5%)	10 (34.5%)	29	0.469
Absent	28 (73.7%)	10 (26.3%)	38	
Host immune response				
Absent	0 (0%)	1 (100%)	1	0.461
Mild	32 (72.7%)	12 (27.3%)	44	
Moderate	10 (66.7%)	5 (33.3%)	15	
Brisk	5 (71.4%)	2 (28.6%)	7	
LVI				
Present	15 (57.7%)	11 (42.3%)	26	0.076
Absent	32 (78%)	9 (22%)	41	

Table 3
Association of galectin-3 and clinicopathological parameters.

Clinicopathological factors	≥50% expression of galectin-3	< 50% expression of galectin-3	Total	P value
Age				
< 51 years (median)	9 (29%)	22 (71%)	31	0.226
≥51 years (median)	6 (16.7%)	30 (83.3%)	36	
Gender				
Male	7 (16.7%)	35 (83.3%)	42	0.145
Female	8 (32%)	17 (68%)	25	
Size				
≤4 cm	2 (18.2%)	9 (81.8%)	11	0.559
> 4 cm, ≤7 cm	5 (21.7%)	18 (78.3%)	23	
> 7 cm. ≤10 cm	6 (33.3%)	12 (66.7%)	18	
> 10 cm	2 (13.3%)	13 (86.7%)	15	
Laterality				
RT	5 (15.6%)	27 (84.4%)	32	0.204
LT	10 (28.6%)	25 (71.4%)	35	
Bilateral	0 (0%)	0 (0%)	0	
Site				
Upper pole	8 (28.6%)	20 (71.4%)	28	0.566
Lower pole	4 (21.1%)	15 (78.9%)	19	
Mid pole	2 (25%)	6 (75%)	8	
Replacing most of kidney	1 (8.3%)	11 (91.7%)	12	
Histological type				
Clear type RCC	9 (22%)	32 (78%)	41	0.006
Papillary type RCC	1 (5.6%)	17 (94.4%)	18	
Cromophobe RCC	5 (62.5%)	3 (37.5%)	8	
Nuclear grade of clear RCC				
1	2 (20%)	8 (80%)	10	0.459
2	6 (31.6%)	13 (68.4%)	19	
3	1 (12.5%)	7 (87.5%)	8	
4	0 (0%)	4 (100%)	4	
Capsular infiltration				
Present	6 (20.7%)	23 (79.3%)	29	0.771
Absent	9 (23.7%)	29 (76.3%)	38	
Perinephric fat infiltrate				
Present	1 (7.1%)	13 (92.9%)	14	0.124
Absent	14 (26.4%)	39 (73.6%)	53	
Sinus infiltrate				
Present	3 (16.7%)	15 (83.3%)	18	0.496
Absent	12 (24.5%)	37 (75.5%)	49	
Tumor stage (pT)				
T1	7 (22.6%)	24 (77.4%)	31	0.776
T2	6 (27.3%)	16 (72.7%)	22	
T3	2 (16.7%)	10 (83.3%)	12	
T4	0 (0%)	2 (100%)	2	
Tumor haemorrahge				
Present	15 (29.4%)	36 (70.6%)	51	0.014
Absent	0 (0%)	16 (100%)	16	
Tumor necrosis				
Present	3 (10.3%)	26 (89.7%)	29	0.039
Absent	12 (31.6%)	26 (68.4%)	38	
Host immune response				
Absent	0 (0%)	1 (100%)	1	0.855
Mild	11 (25%)	33 (75%)	44	
Moderate	3 (20%)	12 (80%)	15	
Brisk	1 (14.3%)	6 (85.7%)	7	
LVI				
Present	4 (15.4%)	22(84.6%)	26	0.273
Absent	11 (26.8%)	30 (73.2%)	41	

equal 0.771, 0.124 and 0.496, respectively (Table 3).

4. Discussion

Galectin-1 and galectin-3 are members of a large family of calcium independent lectins that are involved in a wide range of cellular processes including; growth, proliferation, differentiation, apoptosis, homeostasis, and vascular embryogenesis [7,8]. Several clinical evidences have shown that galectins contribute to neoplastic transformation, tumor cell survival, angiogenesis, and metastasis of tumor in

different organs [7,8].

Several previous reports led to the conclusion that galectin-1 and galectin-3 expression has been positively correlated with aggressiveness of certain tumors, such as mammary carcinomas and colon carcinomas [18,19], whereas it is inversely correlated with tumor progression in certain other tumors, such as uterine and prostate carcinomas [20,21].

The current study found significant difference in the expression of both galectin-1 and galectin-3 in different histological subtypes of RCC. In addition, the expression in neoplastic cells was different from that found in adjacent non-neoplastic tissues. The difference was in the form of overexpression of galectin-1 in RCC in comparison to adjacent tumor-free kidney tissue and the reverse was true regarding galectin-3.

In the present study, galectin-1 and 3 were expressed in adjacent tumor free renal tissue in different patterns. Galectin-1 was expressed in proximal, distal tubules and glomeruli while galectin-3 was expressed in proximal and distal tubules sparing the glomeruli. This suggests that galectin-1 and 3 may play a role in growth of tumors arising from tubular epithelium.

In the current study, the expression of galectin-1 was upregulated in RCC compared to adjacent tumor free renal tissue. This finding was in agreement with other studies [11,22,23]. This result supports the hypothesis proposed by Sakaki et al. that upregulation of galectin-1 may be an early event in cancer development and carcinogenesis [8]. Zuniga et al. [24] have found an association between resistance to treatment of RCC and high expression of galectin-1 in these tumors. They have related that to the effect of galectin-1 in the immune T cell response. Higher levels of galectin-1 have been shown to induce T-cell apoptosis, thereby providing a potential immune escape mechanism [24].

However, the opposite was true regarding galectin-3 expression which was less represented in tumor tissue than adjacent tumor free areas suggesting a tumor suppression role in RCC. This is in agreement with previous study on RCC [25] but contradicting other studies which reported higher expression in tumor tissue when compared to normal renal parynchema [8,26].

This conflict found regarding Galactin-3 might be attributed to different method of evaluation of galactin-3 as Sakaki et al. used real time PCR rather than immunohistochemistry and they evaluated the expression in normal tissue rather than in adjacent tumor free renal tissue which may show molecular changes for tumor development [8]. Some studies assumed that the role of galectin-3 is highly complicated and may be subjected to variation throughout the progression of RCC [25].

Our findings of significant difference in expression of galectin-3 in different histologic subtypes of RCC are in agreement with other studies [23,27,28]. The difference was in the form of high expression of galectin-3 more frequently in Chromophobe RCC than other types. Regarding galectin-1, the highest rate of expression was noted in Chromophobe RCC as all of the eight studied cases showed high expression. Clear RCC showed lowest rate of expression of galectin-1. This observation was different from that found in other studies which showed that the highest expression of galectin-1 was found in clear RCC [23,26,27]. Our finding of high expression of both galectin-1 and galectin-3 in chromophobe RCC suggests a possible diagnostic role of them in that RCC variant. However, the small number of cases of chromophobe RCC included in our study necessitates supporting this finding by further studies on larger number of chrmophobe RCC cases.

Our study showed a statistically significant association between the expression of galectin-1 and the site of tumor as 51% of specimens which showed high expression of galectin-1 were located at the upper pole. This may be attributed to that the majority of our studied tumors were located at the upper renal pole.

Significant inverse association was found between the expression of galectin-3 and presence of tumor necrosis and haemorrahge. The high expression of galectin-3 in normal renal tissue as well as its low expression in tumors with haemorrhage and necrosis suggest a tumor suppression role of galectin-3 in RCC. This is in agreement with other study [25]. Low expression of galectin-3 in tumors with prominent necrosis may be explained by the anti-necrotic role of galectin-3 proved by other studies. Also, this may explain what found in previous studies that tumors with high expression of galectin-3 were resistant to chemotherapeutic drugs [29,30].

Our study didn't show any significant association between the expression level of both galectin-1 and galectin-3 on one hand and the clinicopathological parameters on the other hand as patient age, gender, tumor grade, etc. These findings were in agreement with others [8,25] but were contradicting other studies [23,31] who found the high expression in male patients, in advanced RCC stage and in higher tumor grade. None of the encoding genes of galectin-1 or galectin-3 are located on the sex chromosomes and the increased expression in male patients in some researches may be attributed to the higher prevalence of RCC in male population than in females.

In conclusion, galectin-1 and galectin-3 are overexpressed in significant number of RCC in our locality with different percentage in different subtypes and their expression differs between tumor and adjacent corresponding tumor free renal tissue. Galactin-1 is expressed more in tumor tissue which may indicate a possible role in carcinogenesis of RCC and may be used as a therapeutic agent, the opposite found in galectin-3. Galectin-1 and galectin-3 are overexpressed in chromophobe RCC suggesting a possible role as a diagnostic marker. Galectin-3 is inversely correlated with tumor necrosis which may attribute to chemotherapeutic drug resistance.

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