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Galectin-13 and Integrin: Novel Markers for Assessment the Efficiency of Chemotherapy in Suppressing Solid Tumors

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Abstract

Background: *Cancer remains one of the leading causes of morbidity and mortality worldwide, posing a significant challenge to healthcare systems and medical research. Broadly speaking, tumors can be classified into two main categories: solid tumors and hematologic (liquid) malignancies. While hematologic cancers-such as leukemia and lymphoma-primarily affect the blood and bone marrow, solid tumors are characterized by the abnormal growth of tissue in the form of a mass or lump within a specific organ or body site. Solid tumors encompass a wide range of cancers, including those of the breast, lung, prostate, colon, liver, brain, and many others. These malignancies account for a substantial portion of global cancer cases and deaths, highlighting the urgent need for continued research, early detection, and effective treatment strategies.* ***Patients and Healthy Control*** *a total of 60 individuals were enrolled in the current study, divided into two main groups: The first group (patients): included 30 patients diagnosed with various types of solid malignant tumors, ranging in age from 27 to 77 years. The second group (healthy controls): included 30 healthy individuals, serving as a control group, ranging in age from 26 to 66 years.* ***Kits and technique:*** *Sandwich-ELISA technique was applied to determine the level of*Galectin-13and Integrin*in the serum samples of the study individuals.* ***Results:***the results showed a significant decrease in Galectin-13 levels in the study patients both before (p=0.022) and after receiving treatment (p=0.050) compared to the control group,On the other hand, the results of the current study indicate no significant changes (p=0.707) in Galectin-13 levels in solid tumor patients before receiving chemotherapy and after completing the doses specified by the

specialists.Statistical analysis using an ANOVA test revealed a significant increase in Integrin levels in samples from patients with solid tumors before treatment compared to healthy individuals (p=0.012), while the results indicated that levels of this protein did not decrease significantly after chemotherapy (p=0.389). The study indicated that Integrin levels in patients with solid cancers after chemotherapy declined to levels close to those recorded in the healthy group, with no statistical differences recorded when comparing these two groups (p=0.090),*The study showed that the highest sensitivity*(97%) Galectin-13 and Integrin. The results showed that the combined sensitivity reached its maximum (100%) Galectin-13 and Integrin , while the highest specificity (91%) was recorded for integrins. ***Conclusions:*** Galectin-13 and Integrin *are excellent tools for diagnosing malignant solid tumors.* Integrin *are an effective follow-up function for cancerous tumor detection.*

Key Words Solid Tumors, Galectin-13 **,** Integrin

Introduction

Cancer remains one of the leading causes of morbidity and mortality worldwide, posing a significant challenge to healthcare systems and medical research[1]. The tumors can be classified into two main categories: solid tumors and hematologic (liquid) malignancies, while hematologic cancers-such as leukemia and lymphoma-primarily affect the blood and bone marrow[2]. Solid tumors encompass a wide range of cancers, including those of the breast, lung, prostate, colon, liver, brain, and many others[3]. A tumor is an abnormal growth of tissue that results when cells divide and grow more than they should or do not die when they should[4]. Tumors can form in any part of the body[5]. Solid tumors are abnormal masses of tissue that typically arise from the uncontrolled growth and division of cells within organs or tissues of the body solid tumors are localized and form discrete lumps or masses. They can be benign (non-cancerous) or malignant (cancerous), but in the context of oncology, the term “solid tumors” usually refers to malignant neoplasms[6]. Malignant cells possess immunosuppressive properties, such as the expression of PD-L1 and the secretion of suppressive cytokines, which help them reduce their immunogenicity. The resistance mechanisms of malignant cells can be categorized into two main strategies: evading immune recognition and creating an immunosuppressive TME[7]. Tumorgenesis of solid tumors refers to the complex, multi-step process by which normal cells transform into malignant solid tumors[8]. There are several risk factors that increase the likelihood of developing solid tumors, *e.g.*, tobacco use**,** infections,lifestyle factors**,** and environmental exposures[9].

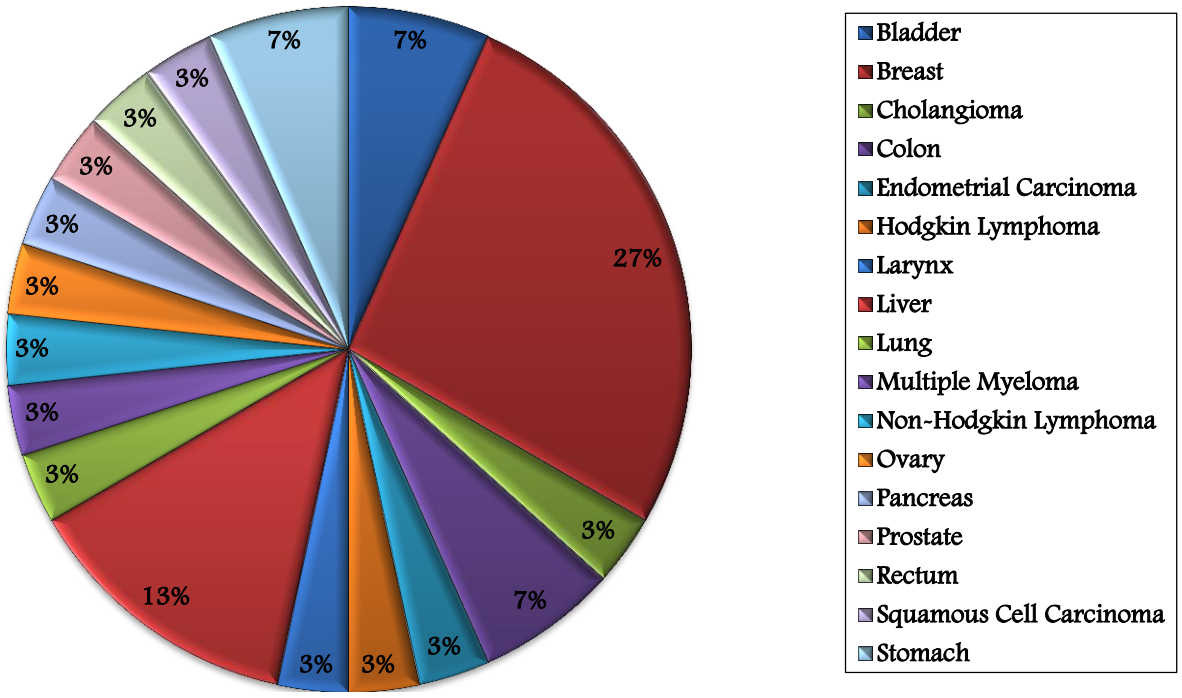
Galectin-13 is a member of the galectins family which are glycan-binding proteins belonging to the lectin. Galectin-13 is a novel marker for airway eosinophilia in asthma and may contribute to allergic airway eosinophilic inflammation by regulating the expression of MCP-1 and eotaxin-1, that Galectin-13 might contribute to airway inflammation in COPD, especially eosinophilic inflammation. Galectin-13 contributes in the induction of apoptosis by activation T cells and regulates the activity of neutrophils suggests important immune functions[10]. Galectin-13 predominantly expressed in the syncytiotrophoblast, amnion, and fetal endothelium, human Galectin-13 is secreted into maternal circulation, where it can induce T cell apoptosis, remodel spiral arteries, and aid in trophoblast invasion of the decidua. Low levels of Galectin-13 in maternal serum may lead to preeclampsia. It is also present in the spleen, kidneys, bladder, and is expressed in conditions such as hepatocellular carcinoma (HCC), neurogenic tumors, and malignant melanoma[11].Tumor cells start to secrete growth factors that activate endothelial cells in nearby vessels in order to trigger the growth of new blood vessels into the expanding tumor mass[12]. Based on the observed dependency on angiogenesis it has been proposed that targeting tumor blood vessel growth could provide an opportunity for cancer therapy galectins have been identified as key regulators of endothelial cell function and tumor angiogenesis. Moreover, vascular galectins have been found to play a significant role in cancer progression, not only in the context of tumor angiogenesis, but also by suppressing an adequate anti-tumor immune response. High percentages of thyroid and lung cancer tissues (>60%) express Galectin-13, so greater attention should be paid to its immunological roles in cancer treatment[13]. Intracellularly, Galectin-13 can interact with the HOX family protein, the upregulation of HOXA1 is also associated with poor prognosis in breast cancer and HCC patients[14].

The “integrin” terminology originates from its function as the integral membrane protein complex bridging the ECM to the cytoskeleton[15]. Integrins are cell adhesion trans membrane receptors that serve as extracellular matrix (ECM)-cytoskeletal linkers and transducer-biochemical and mechanical signals between cells and their environment in a wide range of states in health and diseases since their discovery in the 1980s[16]. Integrins are a large family of heterodimeric cell surface receptors composed of 2 non-covalently associated a- and b subunits that bind to the extracellular matrix and mediate cell adhesion. In mammals, 18 a- and 8 b-subunits have been identified that together form a minimum of 24 distinct integrins, many of which are present in epithelial cells[17]. Integrins can be divided into four types: leukocyte cell-adhesion integrins, Arg-Gly-Asp (RGD)-binding integrins, collagen (GFOGER)-binding integrins, and laminin-binding integrins[18]. Integrin binding with ECM is necessary for cancer initiating cells to sense and respond to the tumor microenvironment Studies indicate that integrins

function as cell surface markers, as well as functional regulators of cancer stem cells, during cancer initiation Integrin α6 also called CD49f, a laminin-binding receptor, is the richest and most common cancer stem cell marker, expressed highly in many cancers including colorectal cancer, breast cancer, skin squamous cell carcinoma and glioblastoma in glioblastoma stem-like cells (GSCs)[19]. Extensive studies have documented numerous integrin functions in tumorgenesis, also it has emerged as a prominent target for cancer prevention and treatment research, and its functions span a broader scope than initially conceived[20]. Recently, the emerging roles of integrins in the regulation of cancer hallmarks have been identified, including "sustaining proliferative signaling," "promoting angiogenesis," "tumor invasion and metastasis," and more. Integrin crosstalk with various cytokines (including epidermal growth factor (EGF), insulin-like growth factor (IGF), transforming growth factorβ (TGF-β), and interleukin-32) has been widely stud[21]. Several studies have indicated that abnormal integrin expression is closely related to multiple type of cancers. As cell surface receptors, integrins can mediate interactions of cancer cells with TME, which is required for various cell activities during tumor formation and progression. Most importantly, due to their specific characteristics, integrins can contribute to tumor growth and provoke cancer deterioration, such as metastasis. Each cancer cell can possess several types of integrin, and one integrin may perform multiple effects depending on the type of cancer cell[22]. Effective marketed treatments have successfully targeted integrins αIIbβ3, α4β7/α4β1 and αLβ2 for cardiovascular diseases, inflammatory bowel disease/multiple sclerosis and dry eye disease, respectively[23].

Materials and Methods

The study population: Over a period of five months (from early October 2024 to the end of March 2025), a total of 60 individuals were enrolled in the current study, divided into two main groups: The first group (patients): included 30 patients diagnosed with various types of solid malignant tumors, ranging in age from 27 to 77 years. The second group (healthy controls): included 30 healthy individuals, serving as a control group, ranging in age from 26 to 66 years. The samples of patients with malignant solid tumors were collected from the National Oncology and Hematology Hospital before receiving chemotherapy and were followed up during the chemotherapy period. This group included 17 different types of cancerous solid tumors (Bladder, Breast, Cholangioma, Colon, Endometrial Carcinoma, Hodgkin Lymphoma, Larynx, Liver, Lung, Multiple Myeloma, Ovary, Pancreas, Prostate, Rectum, Squamous Cell Carcinoma, and Stomach).



All patients with different types of solid tumors were diagnosed by oncologists. Conversely, samples of the healthy control group were collected from the study community environment, such as nursing staff, laboratory workers, and statistical units at the National Oncology and Hematology Hospital, as well as from relatives and the workers in Al-Manathira Specialized Laboratory. The current study required the exclusion of the following individuals:

- Cases with non-solid cancers, such as leukemia
- Cases who did not complete the planned course of chemotherapy
- Cases undergoing chemotherapy sessions due to relapse and recurrence of the cancer.

Cases whose treatment program did not include chemotherapy doses

Assessment of criteria concentration: Sandwich enzyme linked immune sorbent assay (Sandwich-ELISA) method was applied to determine the level ofGalectin-13 and Integrin in the serum samples of the study individuals

The statistical analysis: The outcomes of the present study were analyzed through the statistical package for the social sciences (SPSS) version 26 software application statistical analysis system and excel (statistical package). The variables were illustrated by mean ± S.D, minimum, maximum, frequencies, and percentages. Graphics are presented using pie and bar charts. Inferential data analysis includes analysis of variance (ANOVA) test was applied to assess differences between the levels of the studied parameters. The probability of deflection than controls are considered statistically significant if p-value is below 0.05. Receiver operating characteristic (ROC) curve was applied to present the

sensitivity of the evaluated parameters. Combined sensitivity and specificity percentages were calculated according to biomedical statistical.

Results and Discussion

Galectin-13 levels were measured in serum samples from the study groups, and the results showed a significant decrease in Galectin-13 levels in the study patients both before (p=0.022) and after receiving treatment (p=0.050) compared to the control group, as noted in **Table 1**. On the other hand, the results of the current study indicate no significant changes (p=0.707) in Galectin-13 levels in solid tumor patients before receiving chemotherapy and after completing the doses specified by the specialists.

Table1: Levels of Galectin-13 in The Study Individuals

Subjects (n)	Galectin-13 (ng/L) Mean ± S.D.	Galectin-13 (ng/L) Min-Max	Galectin-13 (ng/L) Range	*p–value*
G_1 (30)	3.560±1.199	1.552-6.263	4.711	0.707 for G_1vs G_2 0.022 for G_1*vs* C 0.050 for G_2*vs*C
G_2 (30)	3.680±1.045	2.152-5.962	3.810	
Controls (30)	4.305±1.438	1.573-7.749	6.176	

G1: Solid Tumor Patients Pre-Treatment, G2: Solid Tumor Patients Post Chemotherapy Treatment. The Mean Difference is Significant at 0.05 Level

The study showed that the highest levels of Galectin-13 (7.749 ng/L) were recorded in the healthy group, while the lowest levels of this protein (1.552 ng/L) were observed in the group of patients with solid tumors. When comparing the results of Galectin-13 levels in the cancer group before and after chemotherapy, the study found no statistically significant differences between the two groups,as shown in **Figure1**. shows a slight increase in Galectin-13 concentrations in the cancer group after receiving three consecutive doses of chemotherapy compared to their pre-treatment levels. For this reason, it is considered an excellent diagnostic tool for distinguishing between cancer patients and healthy individuals, but this criterion is not suitable as a follow-up tool for assessing the response to chemotherapy.

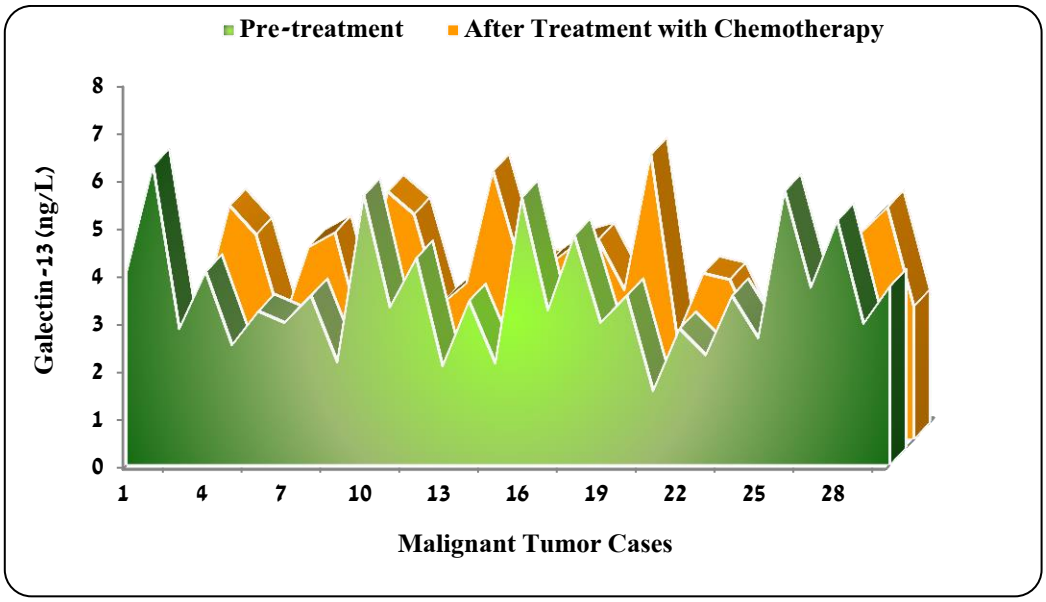


Figure 1: Comparison the Levels of Galectin-13 in Solid Malignant Tumors Patients at Pre and Post Chemotherapy Treatment

Galectin-13 also known as placental protein 13 (PP13), is the most studied galectin of the anthropoid primates. As one of a six cluster primate genes normal term placenta has approximately 2.5 mg of PP13, and, according to Bohn, PP13 represents ~7% of the total placental proteins. PP13 shows structural and functional homologies to the ß-galactoside-binding lectins immunohistochemistry and RNA hybridization studies have pointed to its predominant localization in the placental syncytiotrophoblast layer, placental blood vessels, and specific sites within the placental bed[24].Galectin-13 is a protein belonging to the galectin family, which are proteins that bind to sugars on the surface of cells and play a role in regulating immune responses, cell adhesion, apoptosis, inflammation, and tumor metastasis[25]. It is predictable that galectin is involved in tumor progression homeostasis of the metabolic process is vital for cell growth and stability. Abnormal metabolism promotes a long-term inflammatory response, which also contributes to fibrosis and accompanying tumor genesis. The galectins family is also involved in these processes[26].The findings regarding Galectin-13, are mainly limited to placental tissues. It is worth noting that, despite the lack of studies including normal tissues as control, these galectins are believed to participate in cancer biology studies have shown that galectins play vital roles in multiple processes (e.g. tumorgenesis, metastasis and angiogenesis) of tumor progression. Interestingly, galectins possess diverse functions in different tumors and regulate tumor progression through distinct mechanisms[27]. Galectins are glycan-binding proteins belonging to the lectin subfamily. Galectin-13 is expressed uniquely by the syncytiotrophoblast (STB) in the placenta. The function of Galectin-13 encompasses remodeling of the spiral arteries in the uterus, presenting immune

tolerance of the mother to the offspring. Galectin-13 is secreted into the maternal circulation from as early a stage of pregnancy as the fifth gestational week. Increasing evidence shows the importance of Gal-13 in predicting preeclampsia, fetal growth restriction, and miscarriage, which is associated with an impaired uterine vascular adaptation[28].Generally, 12 meta-analyses evaluated the role of galectins in diagnosis and assessment of cancer They included various cancers (n=2), solid tumors (n=3), thyroid cancer alone (n=4), pancreatic cancer alone (n=1), gastric cancer alone (n=1), and colorectal cancer alone (n=1). Galectin family members have their respective biological behaviors and functions. The clinical evidence has demonstrated the importance of galectins in diagnosis and prognostic assessment of cancer, cardiovascular disease (CVD), nephropathies, skin diseases, and diet-induced steatohepatitis[29]. These galectins play important roles in controlling immune responses within the tumor microenvironment (TME) and the infiltration of immune cells, including different subsets of T cells, macrophages, and neutrophils, to fight against cancer cells. However, these infiltrating cells also have repair roles and are hijacked by cancer cells for pro-tumorigenic activities. Galectin-13 can interact with the HOXA1 family protein. The upregulation of HOXA1 is also associated with poor prognosis in breast cancer and hepatocellular carcinoma (HCC) patients, Its intracellular role(s) should not be neglected[30].In some tumors, Galectin-13 expression is already low, this may be related to cancer cells attempting to evade the immune system, as some galectins (including Galectin-13) play a role in stimulating immune-mediated cell death or regulating tumor-damaging inflammation. Low Galectin-13 expression may reflect aggressive tumor behavior or a genetic mutation that prevents the secretion of this protein as a survival mechanism. Chemotherapy causes tumor cell death and cell death, which may reduce Galectin-13 secretion if some of the cells that secrete it have been killed. Chemotherapy also temporarily suppresses the immune system, which may impair the overall stimulation of galectin production. In some cases, low Galectin-13 expression after treatment may indicate a good response to treatment if it is associated with tumor regression[31].

In the current study, Integrin levels were evaluated in the serum samples for patients and healthy participants. Statistical analysis using an ANOVA test revealed a significant increase in Integrin levels in samples from patients with solid tumors before treatment compared to healthy individuals (p=0.012), while the results indicated that levels of this protein did not decrease significantly after chemotherapy (p=0.389).The study indicated that Integrin levels in patients with solid cancers after chemotherapy declined to levels close to those recorded in the healthy group, with no statistical differences recorded when comparing these two groups (p=0.090), as shown in **Table 2.**

Table2: Levels of Integrin in The Study Individuals

Subjects (n)	Integrin (µg/mL) Mean ± S.D.	Integrin (µg/mL) Min-Max	Integrin (µg/mL) Range	*p - value*
G_1 (30)	30.368±3.782	23.282-39.373	16.091	0.389 for G_1 *vs* G_2
G_2 (30)	29.286±2.601	23.742-34.629	10.887	0.012 for G_1 *vs* C
Controls (30)	27.143±7.016	12.309-40.054	27.745	0.090 for G_2 *vs* C

G1: Solid Tumor Patients Pre-Treatment, G2: Solid Tumor Patients Post Chemotherapy Treatment. The Mean Difference is Significant at 0.05 Level

When monitoring Integrin levels during chemotherapy, a relatively insignificant decrease in this marker was observed after the completion of the first course of treatment (three consecutive doses of chemotherapy) prescribed by the specialist, as shown in **Figure2**., A high level of Integrin in the body indicates the potential for cancer cell growth, while a low level indicates a response to chemotherapy, making it a reliable indicator for monitoring the health status of solid tumor patients. Therefore, this marker can be considered an effective diagnostic tool and for assessing the effectiveness of chemotherapy. Furthermore, it can distinguish between solid tumor patients and healthy individuals and can also help estimate the amount of chemotherapy required for a patient's body to return to the baseline levels observed in healthy individuals.

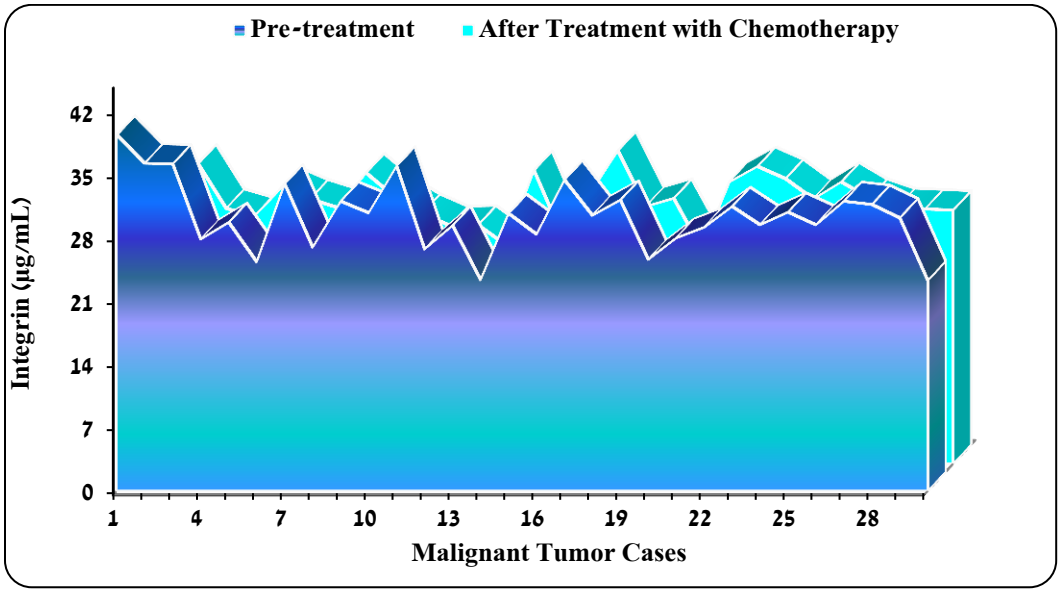


Figure2: Comparison the Levels of Integrin in Solid Malignant Tumors Patients at Pre and Post Chemotherapy Treatment

Integrins are transmembrane adhesion molecules and receptors composed of alpha and beta subunits. Upon binding to extracellular matrix components, integrins induce intracellular signaling and regulate a wide range of cellular functions, including cell survival, proliferation, differentiation, and migration. Because the expression pattern of integrins is a key factor in cell behavior and its response to microenvironmental factors, integrin dysregulation, caused by various mechanisms, has been causally linked to cancer development and progression in many solid tumor types. Integrins are involved in virtually every step of cancer progression, including the initiation of oncogenic transformation and tumor cell proliferation, local invasion and penetration into the vascular system, and the survival of metastatic tumor cells[32]. However, a comprehensive understanding of these roles has not been achieved due to the complex relationships between specific integrins and cancer types and stages of progression. Cancer metastasis is the leading cause of death among cancer patients, and its prevention would significantly reduce cancer-related deaths. Integrins are a target for cancer therapeutics under development[33]. Because integrin activity stimulates signaling events, including and particularly those that direct intercellular communication, their role in early developmental pathways of organisms is well recognized and studied. Integrins act as key molecular linkers between cells and the extracellular matrix (ECM), adhesion molecules, and plasma proteins[34].Integrins, which comprise 18 alpha subunits and 8 beta subunits, play an important role in the progression and homeostasis of non-small cell lung cancer (NSCLC). However, there is a clear variability in the ITG subunits that play a critical role in different lung cancer subtypes. Furthermore, inhibitors targeting integrins have attracted significant interest as a novel strategy for various tumor types[35]. The integrin family of adhesion receptors is well known for its key role in B cell infiltration and migration. Less well known, but equally important, is its role in stabilizing immune synapses and contributing to B cell receptor signaling. Given the mechanoreceptor nature of integrins and their connection to the actin cytoskeleton, it is clear that integrins modulate the assembly processes of dendritic cell receptors, thereby inhibiting autoimmunity and participating in dendritic cell receptor- and antigen-independent signaling[36].Despite significant advances in understanding cancer biology and its molecular characteristics, which have led to improved early diagnosis and therapeutic options for many cancers, new therapeutic strategies remain, especially for some cancers. In particular, the metastatic stage of many cancers, such as breast cancer, colorectal cancer, pancreatic ductal adenocarcinoma, lung cancer, and renal clear cell carcinoma, still requires new and improved therapies[37].In the current study, an increase in integrin levels was observed in a group of patients with solid tumors before receiving chemotherapy. This is explained by the fact that during the carcinogenesis process, solid tumors over-

express certain types of integrins, such as αvβ3 and α5β1, to promote cancer cell migration, invasion of neighboring tissues, interaction with immune cells and the tumor microenvironment, and resistance of cancer cells to apoptosis. Cancer cells and the surrounding stroma, such as fibroblasts and endothelial cells, secrete signals that stimulate integrin expression. The low-oxygen environment (hypoxia) in the tumor also stimulates an increase in integrins.The decrease in integrin levels was slight and insignificant after receiving a course of chemotherapy, this may be explained by the fact that chemotherapy does not directly target integrins, as it mostly targets DNA or cell division, but does not directly affect adhesion pathways or integrin expression. Furthermore, some tumors may develop resistance to chemotherapy by enhancing integrin expression, helping cells survive the effects of the drugs. On the other hand, chemotherapy may reduce the number of cancer cells, but it does not necessarily eliminate immune cells or stroma, which continue to secrete integrin stimulants. Chemotherapy also causes tissue stress, leading to an inflammatory response, which in turn may increase integrin expression.

Efficiency of the evaluated parameters in detection of different solid tumors

Sensitivity is known as the true positive rate or the probability of detection, it measures the proportion of positives that are correctly identified.Specificity is known as the true negative rate; it measures the proportion of negatives that are correctly identified.The calculation of sensitivity and specificity is used for assessing the efficiency of the tested parameters to suggest them as diagnostic markers. The diagnostic efficiency of the included criteria in this work were evaluated by applying the receiver operating characteristic (ROC) as demonstrated **in Figurers 3**and**4**forGalectin-13, Integrinrespectively. **Table 3** shows the area under the curve and threshold values for the parameters evaluated in patients with solid tumors before receiving chemotherapy. The study showed that the highest sensitivity (**83**%) for Galectin-13, while the highest sensitivity (**84**%) and the highest specificity (91%) was recorded for integrins.

Table 3: Receiver Operating Characteristic Analysis of the Evaluated Criteria as Diagnostic Markers for Solid Tumors

Criteria	AUC	SE	p-value	Cutoff value	Sensitivity%	Specificity%	CI (95%)
Galectin-13	0.324	0.051	0.019	3.323	83	80	0.185-0.464
Integrin	0.661	0.074	0.032	26.546	84	91	0.517-0.806

AUC: Area Under Curve, SE: Standard Error

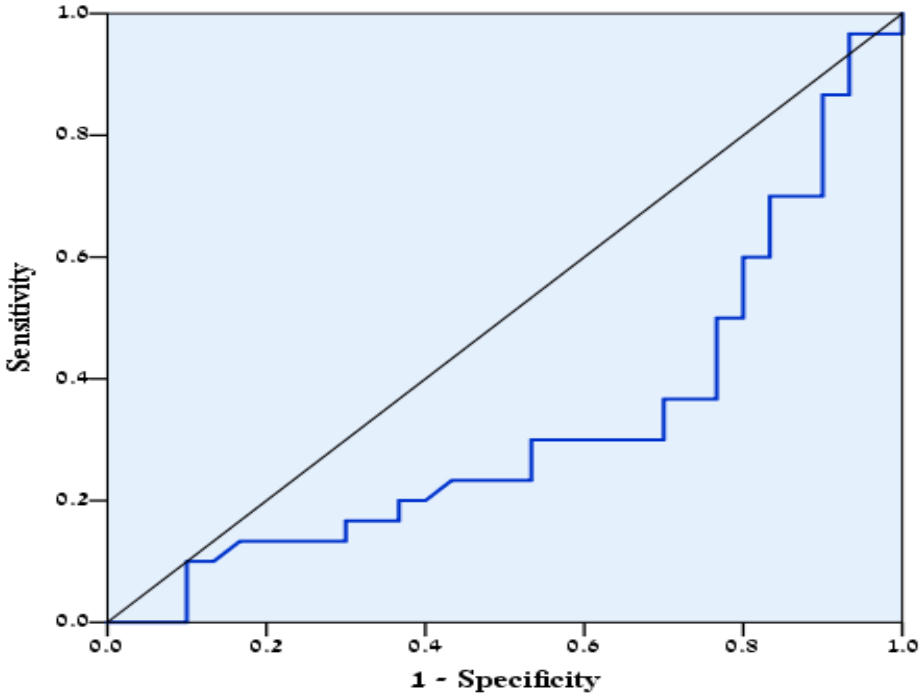


Figure 3: Receiver Operating Characteristic Curve of Galectin-13in Solid Malignant Tumors Patients Before Chemotherapy

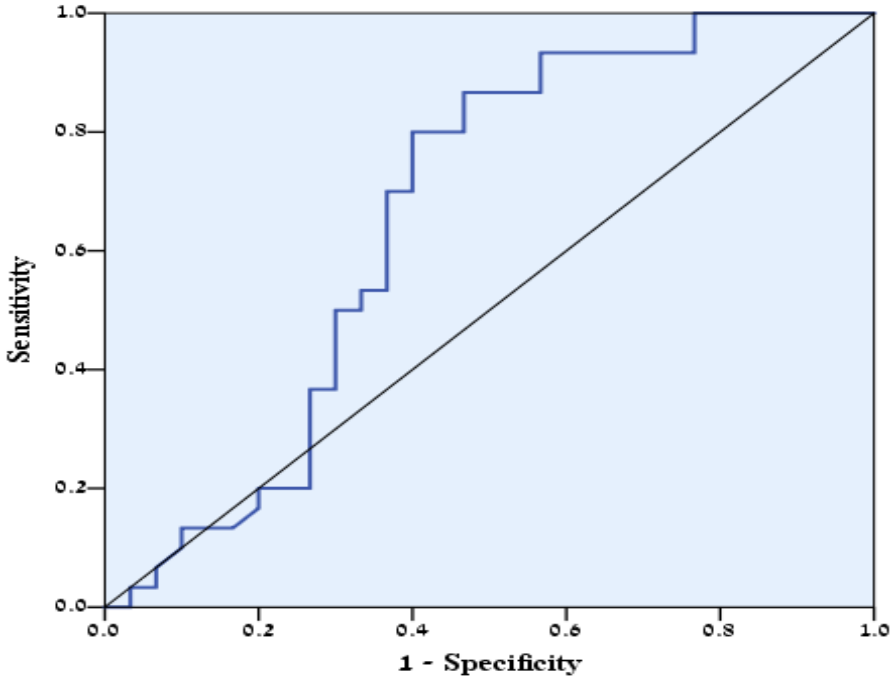


Figure4: Receiver Operating Characteristic Curve of Integrin in Solid Malignant Tumors Patients Before Chemotherapy

The combined sensitivity of the criteria: Galectin-13, Integrin was evaluated in the solid tumor cohort before chemotherapy, as shown in **Table 4**. All criteria demonstrated equally maximal sensitivity in this study, with each reaching

100%.While of Galectin-13 and Integrin, they were sensitivity to them 97% before Chemotherapy Treatment.

Table4: The Combined Sensitivity of the Evaluated Parameters before Chemotherapy Treatment

Parameters	Galectin-13	Integrin
Galectin-13	-	97
Integrin		-

Table 5 shows the area under the curve and threshold values for the criteria evaluated in a group of solid tumor patients who received chemotherapy. The study showed that the highest sensitivity (**80**%) and highest specificity (**76**%) were recorded for Galectin-13.

Table 5: Receiver Operating Characteristic Analysis of Evaluated Parameters as Predictive Markers of Response to Chemotherapy

Criteria	AUC	SE	p-value	Cutoff value	Sensitivity%	Specificity%	CI (95%)
Galectin-13	0.364	0.072	0.070	3.413	80	76	0.222-0.505
Integrin	0.621	0.079	0.107	26.943	83	76	0.466-0.776

AUC: Area Under Curve, SE: Standard Error

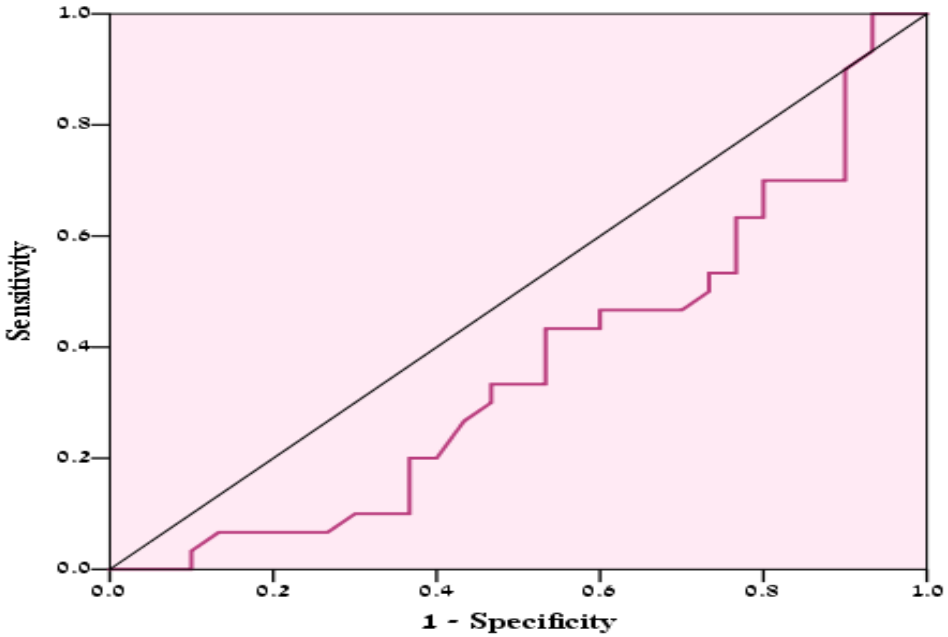


Figure5: Receiver Operating Characteristic Curve of Galectin-13 in Solid Malignant Tumors Patients After Chemotherapy

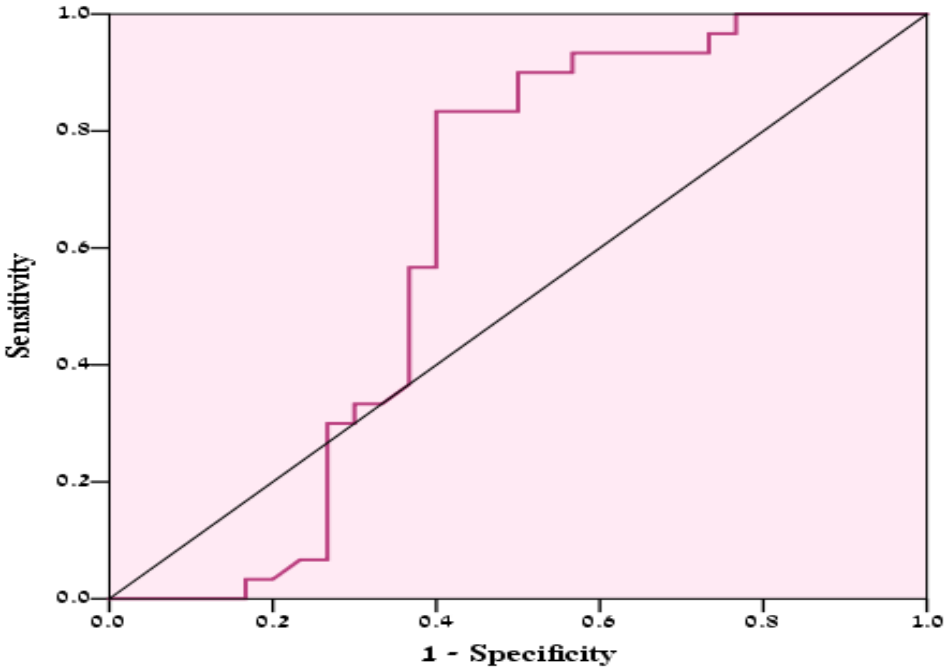


Figure 6:Receiver Operating Characteristic Curve of Integrin in Solid Malignant Tumors Patients After Chemotherapy

While the combined sensitivity of the criteria Galectin-13, and Integrin was evaluated for solid tumors after chemotherapy, as shown in **Table 6**. The results showed that the combined sensitivity reached its maximum (100%) for Galectin-13 and Integrin, as well as when combining Integrin sensitivity with Galectin-13, respectively.

Table 6: The Combined Sensitivity of the Evaluated Parameters after Chemotherapy Treatment

Parameters	Galectin-13	Integrin
Galectin-13	-	100
Integrin		-

References

[1] Israel Osejie Okoduwa, Bankole Ibrahim Ashiwaju, Jane Osareme Ogugua, Jeremiah Olawumi Arowoogun, Kehinde Feranmi Awonuga, and Evangel Chinyere Anyanwu, "Reviewing the progress of cancer research in the USA," *World J. Biol. Pharm. Heal. Sci.*, vol. 17, no. 2, pp. 068–079, 2024, doi: 10.30574/wjbphs.2024.17.2.0046.

[2] F. W. Janssen *et al.*, "A comprehensive overview of liquid biopsy applications in pediatric solid tumors," *npj Precis. Oncol.*, vol. 8, no. 1, 2024, doi: 10.1038/s41698-024-00657-z.

[3] M. R. MacLean, O. L. Walker, R. P. Arun, W. Fernando, and P. Marcato,

"Informed by Cancer Stem Cells of Solid Tumors: Advances in Treatments Targeting Tumor-Promoting Factors and Pathways," *Int. J. Mol. Sci.*, vol. 25, no. 7, 2024, doi: 10.3390/ijms25074102.

[4] X. Jing and Y. Deng, "ADCYAP1 as a pan-solid cancer biomarker: predictor of immunotherapy efficacy in bladder cancer and prognostic potential across solid tumors," *Discov. Oncol.*, vol. 16, no. 1, 2025, doi: 10.1007/s12672-025-02408-3.

[5] F. H. Al-Ostoot, S. Salah, and S. A. Khanum, "An Overview of Cancer Biology, Pathophysiological Development and It's Treatment Modalities: Current Challenges of Cancer anti-Angiogenic Therapy," *Cancer Invest.*, vol. 42, no. 7, pp. 559–604, 2024, doi: 10.1080/07357907.2024.2361295.

[6] S. Dalaf Khalaf, M. M. Mahdi, and R. Shakir Mahmood, "the Cancer: Types, the Mechanism of Caner Growth and Diagnosis: a Review," *World J. Pharm. Sci. Res.*, vol. 3, no. July, p. 2024, 2024, [Online]. Available: www.wjpsronline.com

[7] S. Y. Park *et al.*, "Harnessing myeloid cells in cancer," *Mol. Cancer*, vol. 24, no. 1, p. 69, 2025, doi: 10.1186/s12943-025-02249-2.

[8] Y. Zheng, L. Wu, Z. Hu, H. Liao, and X. Li, "Role of the Forkhead box family protein FOXF2 in the progression of solid tumor: systematic review," *J. Cancer Res. Clin. Oncol.*, vol. 151, no. 1, 2025, doi: 10.1007/s00432-024-06047-z.

[9] S. Farina, A. Sabatelli, S. Boccia, and G. Scambia, "Environment, lifestyle, and cancer in women," *Int. J. Gynecol. Obstet.*, no. March, pp. 1–9, 2025, doi: 10.1002/ijgo.70156.

[10] N. Zhang *et al.*, "Multifaceted roles of Galectins: from carbohydrate binding to targeted cancer therapy," *Biomark. Res.*, vol. 13, no. 1, pp. 1–51, 2025, doi: 10.1186/s40364-025-00759-1.

[11] N. Karadzov Orlic and I. Joksić, "Preeclampsia pathogenesis and prediction - where are we now: the focus on the role of galectins and miRNAs," *Hypertens. Pregnancy*, vol. 44, no. 1, 2025, doi: 10.1080/10641955.2025.2470626.

[12] B. Zyli, "Role and Mechanisms of Angiogenesis in Tumours," pp. 1–20, 2025.

[13] C. Fuselier *et al.*, "Placental Galectins in Cancer: Why We Should Pay More Attention," *Cells*, vol. 12, no. 3, 2023, doi: 10.3390/cells12030437.

[14] R. Jacob and L. S. Gorek, "Intracellular galectin interactions in health and disease," *Semin. Immunopathol.*, vol. 46, no. 1–2, 2024, doi: 10.1007/s00281-

024-01010-z.

[15] L. T. Timmer *et al.*, "Cardiomyocyte SORBS2 expression increases in heart failure and regulates integrin interactions and extracellular matrix composition," *Cardiovasc. Res.*, vol. 121, no. 4, pp. 585–600, 2025, doi: 10.1093/cvr/cvaf021.

[16] F. Niedergang, R. Chabrier, and I. Tardieux, "Meeting Report on the Symposium Organized to Celebrate the 40th Anniversary of the French Society for Cell Biology," *Biol. Cell*, vol. 117, no. 7, pp. 1–11, 2025, doi: 10.1111/boc.70014.

[17] Å. Norén *et al.*, "Proteomic analysis of human kidney biopsies unveils emerging acute kidney injury very early after liver graft reperfusion," *J. Transl. Med.*, vol. 23, no. 1, 2025, doi: 10.1186/s12967-025-06695-w.

[18] L. Zhang, Z. Zhang, R. Yang, G. Zhang, and Y. Wang, "Pr ep rin ot pe er re v Pr ep rin ot pe er ed," *Ssrn*, no. 211, pp. 1–8, 2025.

[19] C. Zechel *et al.*, *Molecular signature of stem-like glioma cells (SLGCs) from human glioblastoma and gliosarcoma*, vol. 19, no. 2 February. 2024. doi: 10.1371/journal.pone.0291368.

[20] C. Su, J. Mo, S. Dong, Z. Liao, B. Zhang, and P. Zhu, "Integrinβ-1 in disorders and cancers: molecular mechanisms and therapeutic targets," *Cell Commun. Signal.*, vol. 22, no. 1, pp. 1–24, 2024, doi: 10.1186/s12964-023-01338-3.

[21] J. Xue *et al.*, "The interaction of platelet-related factors with tumor cells promotes tumor metastasis," *J. Transl. Med.*, vol. 22, no. 1, pp. 1–13, 2024, doi: 10.1186/s12967-024-05126-6.

[22] Z. Liu *et al.*, *Focal adhesion in the tumour metastasis: from molecular mechanisms to therapeutic targets*, vol. 13, no. 1. 2025. doi: 10.1186/s40364-025-00745-7.

[23] J. Mei *et al.*, "Anoikis in cell fate, physiopathology, and therapeutic interventions," *MedComm*, vol. 5, no. 10, pp. 1–32, 2024, doi: 10.1002/mco2.718.

[24] A. Bokulich, "Models and Analogies in the Reconstruction of Extinct Life," pp. 1–24, 2021.

[25] W. Chen, "The role of glycan-lectin interactions in the tumor microenvironment: immunosuppression regulators of colorectal cancer," *Am. J. Cancer Res.*, vol. 15, no. 4, pp. 1347–1383, 2025, doi: 10.62347/wbjl4045.

[26] B. Stojanovic *et al.*, "Galectins as Master Regulators of Gastric Cancer Progression," pp. 1–37, 2025.

[27] E. Purić, U. J. Nilsson, and M. Anderluh, "Galectin-8 inhibition and functions in immune response and tumor biology," *Med. Res. Rev.*, vol. 44, no. 5, pp. 2236–2265, 2024, doi: 10.1002/med.22041.

[28] E. Tóth *et al.*, "Decreased Expression of Placental Proteins in Recurrent Pregnancy Loss: Functional Relevance and Diagnostic Value," *Int. J. Mol. Sci.*, vol. 25, no. 3, 2024, doi: 10.3390/ijms25031865.

[29] E. Michalopoulou *et al.*, "The Triad of Risk: Linking MASLD, Cardiovascular Disease and Type 2 Diabetes; From Pathophysiology to Treatment," *J. Clin. Med.*, vol. 14, no. 2, 2025, doi: 10.3390/jcm14020428.

[30] F. D. E. De Palma *et al.*, "Epigenetic regulation of HOXA2 expression affects tumor progression and predicts breast cancer patient survival," *Cell Death Differ.*, vol. 32, no. 4, pp. 730–744, 2025, doi: 10.1038/s41418-024-01430-2.

[31] P. G. J. de Boissel *et al.*, "Development and Use of a Galectin-1-Specific Nanobody for Tumor Imaging and Elucidating the Role of Galectin-1 in Cancer," *ACS Pharmacol. Transl. Sci.*, 2025, doi: 10.1021/acsptsci.5c00178.

[32] D. Cáceres-Calle *et al.*, "Integrins as Key Mediators of Metastasis," *Int. J. Mol. Sci.*, vol. 26, no. 3, 2025, doi: 10.3390/ijms26030904.

[33] Y. Li, S. Peng, J. Xu, W. Liu, and Q. Luo, "Integrin signaling in tumor biology: mechanisms of intercellular crosstalk and emerging targeted therapies," *PeerJ*, vol. 13, no. 5, pp. 1–45, 2025, doi: 10.7717/peerj.19328.

[34] F. Napolitano, M. Fabozzi, and N. Montuori, "Non-Integrin Laminin Receptors: Shedding New Light and Clarity on Their Involvement in Human Diseases," *Int. J. Mol. Sci.*, vol. 26, no. 8, pp. 1–19, 2025, doi: 10.3390/ijms26083546.

[35] A. Armstrong, "Drug Conjugates : A New Hope for Cancer," pp. 1–22, 2025, doi: 10.1002/psc.70040.

[36] C. L.- L, "cells is modulated via an interplay between CD54 / ICAM-1 and," 2025.

[37] D. Sherpally and A. Manne, "Advancing Immunotherapy in Pancreatic Cancer: A Brief Review of Emerging Adoptive Cell Therapies," *Cancers (Basel).*, vol. 17, no. 4, pp. 1–21, 2025, doi: 10.3390/cancers17040589.