

# Over-expression of HER-2 is associated with the stage in carcinomas of the urinary bladder

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**Background:** The frequency of over-expression of human epidermal growth factor receptor-2 (HER-2) in bladder cancer is one of the highest among all human malignancies. This over-expression is thought to play a role in aberrant proliferation of cancer cells. Studies on HER-2 expression in bladder carcinoma have shown heterogeneous results.

**Purpose:** The aim of the study was to evaluate the status of HER-2 protein expression in patients with invasive carcinomas of the urinary bladder as related to tumor grade and stage.

**Materials and methods:** Archival samples from 39 patients (6 women, 33 males) with urinary bladder cancer were analyzed for HER-2 over-expression, using immunohistochemistry with the HercepTest.

**Results:** HER-2 over-expression was observed in 23/39 tumors (59%) and was more frequent in high-grade than in low-grade carcinomas, but the difference was not statistically significant. A significant correlation was established between HER-2 over-expression and tumor stage ( $p=0.011$ ). HER-2 expression was more frequent in transitional cell carcinomas (TCC) and adenocarcinomas (AC) as compared with squamous cell carcinoma (SCC). Patients' age and sex were not related to HER-2 over-expression.

**Conclusion:** Over-expression of HER-2 was frequent in carcinomas of the urinary bladder. Knowing the HER-2 status would be helpful in formulating a rational treatment strategy for patients with urinary bladder cancer.

Keywords: *bladder cancer; human epidermal growth factor receptor-2; immunohistochemistry; over-expression*

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Bladder cancer is a common malignancy in the genitourinary tract, and transitional cell cancer (TCC) accounts for >90% of all bladder cancers. It is a prevalent disease and ranks ninth in the global cancer incidence, with 356,000 annual new cases and 145,000 annual deaths (1, 2). Bladder cancers are classified as superficial (80%) and invasive disease (20%) on the basis of their histological appearance. Transurethral resection (TUR) with or without intravesical treatment is the therapy-of-choice in superficial bladder cancers, while radical cystectomy is needed in invasive disease (3, 4). However, 5-year survival rates following radical treatment for tumors of all stages remain low, around 40–50%, due to a high risk of recurrence or occult metastasis (5, 6).

Despite the fact that the most common prognostic markers are conventional clinico-pathologic parameters, such as tumor stage and grade, which are subject to

considerable intra- and inter-observer variation, it is difficult to predict accurate prognosis with any single factor. However, accurate estimation of the biological behavior of these tumors is important to select the appropriate treatment. Therefore, more reliable prognostic factors are urgently needed, the prime interest being currently focused on protein and genetic markers (7–9).

Human epidermal growth factor receptor-2 (HER-2) is a trans-membrane tyrosine kinase receptor of the epidermal growth factor (EGF) receptor family. HER-2 plays a fundamental role in cell growth, survival, and migration, and abnormal activation of HER-2 has been proposed to lead to oncogenic transformation. The role of HER-2 has been most thoroughly studied in breast cancer, where constitutively active HER-2 is over-expressed in 18–22% of cases and shown to correlate with a poor prognosis (10, 11).

It has been shown that this protein is involved in pathogenesis of urinary bladder carcinomas as well, to an

extent almost comparable to breast cancer (12, 13). However, the prognostic value of this protein in bladder cancer has not been well established, and also the true prevalence of HER-2 expression in this disease remains uncertain. A possible involvement of HER-2 receptor in the proliferation of invasive urothelial carcinomas has prompted trials with HER-2 targeted therapies in locally advanced or metastatic disease (14).

In this retrospective study, we used immunohistochemistry (IHC) to evaluate the HER-2 protein expression in bladder carcinomas in relation to tumor histology, grade and stage.

## Material and methods

### Clinical samples

Archival samples of 39 invasive urinary bladder carcinomas was examined in the present study: All the tumor samples were collected from the Pathology Department, Faculty of Medicine, Garyounis University, Benghazi, Libya, derived from years 2006 to 2010. Only invasive bladder tumors were included based on availability of representative paraffin blocks. Of these 39 cases, 33 patients were male and 6 were women, with the mean age of 64.5 years (range: 47–80 years). Histological diagnosis and tumor grading were performed by an experienced pathologist, following the World Health Organization (WHO) classification. Clinical staging was made according to the American Joint Committee on Cancer system in a blinded fashion. Key features of the patients and their tumors are shown in Table 1.

### Immunohistochemical (IHC) method for HER-2

Paraffin-embedded tumor specimens were cut at 5 µm and subjected to IHC staining with the Food and Drug Administration (FDA)-approved HercepTest® (Ventana Medical System, Inc., Tucson, AZ, USA). The IHC analysis was done using an automated system (Benchmark XT, Ventana Medical System, Tucson, AZ, USA). In brief, tissue sections were incubated with the primary HER-2 antibody (Confirm™, Anti HER-2 primary antibody/4BS), followed by the secondary antibody, peroxidase-anti-peroxidase complex (PAP), and final detection of immunoreactivity by the diaminobenzidine (DAB) substrate. After staining, the sections were dehydrated in ethanol, cleared in xylene, and covered with Mountex and cover slips.

### Scoring of HER-2 over-expression

Stained sections were reviewed independently by two pathologists, both blinded to the clinical outcome. Scoring was done using the following system: 1+, at most faint, equivocal, and incomplete membranous staining; 2+, unequivocal, complete membranous pattern, with moderate intensity; and 3+, complete and

**Table 1.** Key features of the patients and their tumors

Variable	Number	Percentage%
<b>Patients</b>		
Male	33	84.6
Female	6	15.4
<b>Age (years)</b>		
Range	47–80	–
Mean	64.51	–
Median	67.00	–
<b>Histological type</b>		
TCC	36	92.3
AC	1	2.6
SCC	2	5.1
<b>Grade</b>		
Low grade	27	69.2
High grade	12	30.8
<b>Stage</b>		
Stage 1	29	74.4
Stage 2	9	23.1
Stage 3	1	2.5

TCC, transitional cell carcinoma; AC, adenocarcinoma; SCC, squamous cell carcinoma.

strong membranous pattern. Tumors with a score of 2 or 3 were considered as HER-2 positive (15). The staining index (*I*) was calculated using the following formula:

$$I = 0 * f_0 + 1 * f_1 + 2 * f_2 + 3 * f_3$$

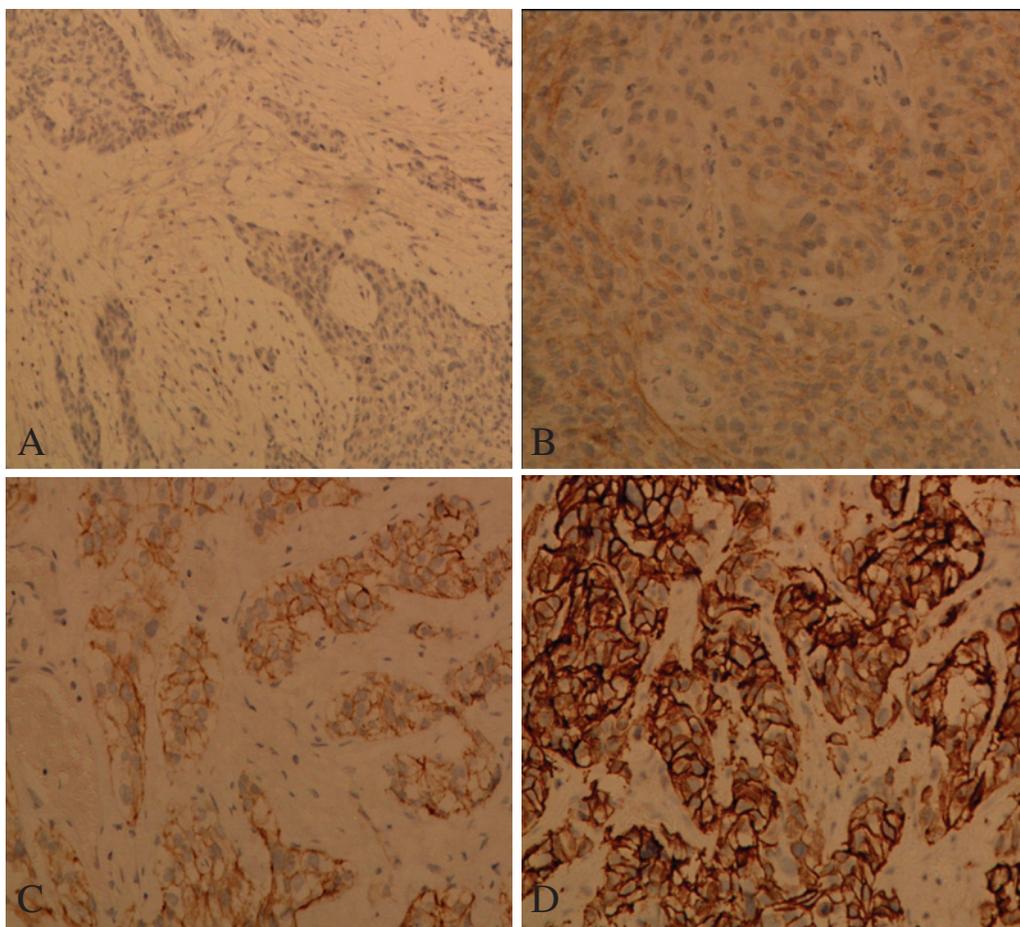
Where *f*<sub>0</sub>, *f*<sub>1</sub> and *f*<sub>3</sub> represent the fraction of the cells showing a defined level of staining intensity (from 0 to 3). Theoretically, the index ranges from 0 to 3 (16, 17).

### Statistical analysis

SPSS for Windows SPSS 19.0.1 (IBM, NY, USA) was used for statistical analysis. Frequency tables were analyzed using the Chi-square test, with Fisher's exact test (where appropriate), or likelihood ratio (LR) statistics to assess the significance between categorical variables. Differences in the means of continuous variables were analyzed using ANOVA (analysis of variance) or non-parametric tests (Mann-Whitney, Kruskal-Wallis) tests. Reported p-values are from two-sided tests, and in all analysis *p* < 0.05 was regarded as statistically significant.

## Results

In interpreting HER-2 immunostaining, HER-2 positivity was indicated by membranous golden-brown staining. The cases with only cytoplasmic staining were considered negative, irrespective of the staining intensity. Of the 39 bladder carcinomas, 16 (41%) were considered negative (staining intensity 0 or 1+ in 4 and 12 patients, respectively) (Fig. 1 A, B), whereas 23 (59%) were considered positive (staining intensity 2+ or 3+ in 10



**Fig. 1.** HER-2 immunostaining of invasive urothelial carcinoma cells showing: (A) IHC 0 score ( $\times 100$ ), (B) IHC +1 score ( $\times 200$ ), (C) IHC +2 score ( $\times 200$ ) and (D) IHC +3 score ( $\times 200$ ).

and 13 patients, respectively) (Fig. 1C,D). HER-2 expression was invariably negative in the normal urothelium adjacent to the tumor (Fig. 2).

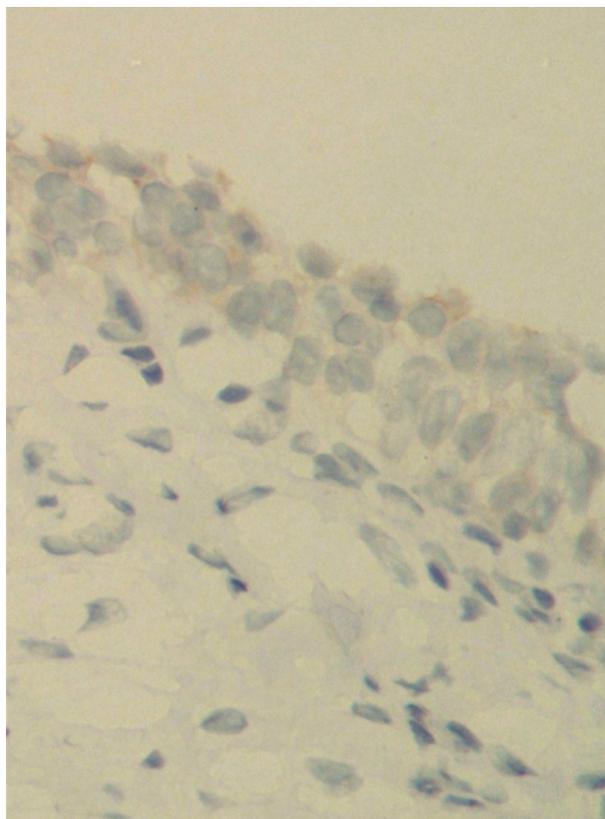
The present study revealed a significant correlation between HER-2 expression and the tumor stage ( $p = 0.011$ ). Although there was no statistically significant association ( $p = 0.21$ ) between HER-2 and tumor grade, HER-2 showed over-expression more often in high-grade (8/12, 66.6%) than in low-grade tumors (12/27 44.4%). HER-2 did not show any correlation with age or sex. However, HER-2 expression was higher in TCC and adenocarcinomas (AC) as compared to squamous cell carcinoma (SCC) ( $p = 0.029$ ) despite the small number of AC and SCC samples used. The associations of HER-2 expression with clinical and pathological variables are shown in Table 2.

## Discussion

The first report of increased amplification and expression of the HER-2 in bladder carcinoma (18) enthused interest in the role of this oncogene in tumor progression. Prevalence of HER-2 expression in urothelial carcinomas

has ranged from 2% to 81% (19–34). Moreover, its prognostic significance is highly controversial, with several conflicting results in the literature. Thus, although some studies (24, 26) have found correlation between HER-2 amplification/over-expression and more aggressive clinical behavior, others (19, 21, 25) have found no such prognostic significance, and still some others (20, 22, 23, 27) have linked HER-2 with a more favorable clinical outcome. Differences in the frequency of HER-2 expression and its prognostic significance in urothelial cancer are most likely explained by the use of different techniques, including assessment of the HER-2 status (i.e. gene amplification or protein over-expression), detection methods (i.e. PCR, fluorescence *in situ* hybridization, and IHC), as well as definition of HER-2 positivity. Thus, the available literature in this field is extremely difficult to compare, and definite conclusions are hard to draw from the accumulated data.

In the present series, there was a positive HER-2 status in 23 (59%) cases of bladder cancer. This rate is within the range of previously published data. Previous studies on HER-2 expression in bladder carcinoma using Western



**Fig. 2.** Normal urothelium showing negative HER-2 immunostaining ( $\times 400$ ).

blot analysis and IHC have found a correlation between increased HER-2 expression and both higher tumor stage and grade (35–39). Our study confirmed these findings.

We assessed HER-2 expression by IHC, which is the method most commonly used also for HER-2 status determination in breast cancer, and we found a significant correlation between HER-2 over-expression and tumor stage ( $p=0.011$ ), and a trend (albeit not significant) for higher HER-2 expression with high-grade tumors. Others (19, 27, 40) have reported a significant association between HER-2 over-expression and a higher tumor grade, but not with the tumor stage. Thus, Krüger et al. (41) studied HER-2 expression in patients undergoing radical cystectomy for muscle-invasive carcinoma using the Hercep Test. HER-2 over-expression was associated with high-grade bladder cancers but showed no correlation with the tumor stage. Similarly, in a recent study (42) on 59 patients, HER-2 over-expression was significantly correlated with the differentiation grade but not with the tumor stage.

In two other studies (43, 44) there was no significant association between HER-2 and either pathological staging or tumor grading. Similarly, in a series of 53 bladder cancers, no significant correlation was found between HER-2 and stage or grade (45). Furthermore, in that study, the authors reported no significant difference between TCC and SCC groups, which is in contrast to our current study, where HER-2 expression was significantly more frequent in TCC and AC than in SCC ( $p=0.029$ ), notwithstanding the small number of AC and SCC samples in the current study.

It seems likely that the reported variations in HER-2 expression in urothelial cancer may be the result not only of true biological variations but also of several confounding variables in these studies. These include the use of different

**Table 2.** The associations of HER-2 expression with clinical and pathological variables

Variable	N (%)	HER-2 expression status N (%)				P
		0	+1	+2	+3	
Total	39 (100)	4 (10.2)	12 (30.8)	10 (25.7)	13 (33.3)	–
Gender						
Female	6 (15.4)	1 (16.7)	0 (0)	2 (33.3)	3 (50)	0.17
Male	33 (84.6)	3 (9.1)	12 (36.3)	8 (24.2)	10 (30.4)	
Stage						
I	29 (74.4)	3 (10.3)	11 (38)	9 (31)	6 (20.7)	0.011
II	9 (23.1)	1 (11.1)	1 (11.1)	1 (11.1)	6 (66.7)	
III	1 (2.5)	0 (0)	0 (0)	0 (0)	1 (100)	
Grade						
Low grade	27 (69.2)	4 (14.8)	11 (40.7)	7 (26)	5 (18.5)	0.21
High grade	12 (30.8)	2 (16.6)	2 (16.6)	2 (16.6)	6 (50)	
Histological type						
TCC	36 (92.3)	4 (11.1)	13 (36.1)	9 (25)	10 (27.8)	0.029
AC	1 (2.6)	0 (0)	0 (0)	0 (0)	1 (100)	
SCC	2 (5.1)	2 (100)	0 (0)	0 (0)	0 (0)	

TCC, transitional cell carcinoma; AC, adenocarcinoma; SCC, squamous cell carcinoma.

antibodies for IHC, different criteria for IHC-positivity (i.e. cytoplasmic or membrane staining), and different scoring criteria.

Despite the inconclusive data on the prognostic value of HER-2 as an independent marker of tumor progression, there may be a therapeutic role for an anti HER-2 agent such as trastuzumab in cancer treatment. Available data clearly demonstrate that the development of new drugs will have little, if any, chance of success if it is not guided by in-depth knowledge of disease biology. However, using biologic agents to target key molecular pathways, such as those regulated by HER family members, may be effective. Indeed, the positive results achieved by trastuzumab in breast and gastric HER-2 positive tumors support this approach (46). Combining trastuzumab with chemotherapy in HER-2 positive advanced gastric cancer was significantly more effective than chemotherapy alone (47) and has a favorable toxicity profile (48). The efficacy of trastuzumab in breast and gastric cancer patients has led to investigation of its antitumor activity in patients with HER-2 positive cancers, including urothelial carcinomas. Therefore, all patients with advanced or metastatic bladder cancers should be tested for HER-2 status for selection of proper candidates who may benefit from adjuvant HER-2 targeted therapy.

## Conclusion

The present study demonstrates a statistically significant ( $p=0.011$ ) association between HER-2 over-expression and increased tumor stage, as well as a statistically insignificant ( $p=0.21$ ) increase in protein expression in higher grade tumors. Assessment of HER-2 status can be helpful in identifying patients at high-risk of disease progression who may benefit from adjuvant HER-2-targeted therapy after radical cystectomy. Future prospective studies on HER-2 expression with chemosensitivity and efficacy of HER-2-targeted therapies in urothelial carcinomas are warranted.

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