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ORIGINAL RESEARCH

Oxidative Stress Markers and Antioxidant Levels in Cervical Cancer: A Comparative Analysis with Healthy Controls and Correlation with Disease Severity

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ABSTRACT

Background: Oxidative stress plays a significant role in the pathogenesis and progression of cervical cancer. This study investigates the levels of oxidative stress markers in cervical cancer patients compared to healthy controls and examines their association with disease severity. **Methods:** A total of 128 participants, including 100 cervical cancer patients and 28 healthy controls, were enrolled. The study analyzed serum levels of malondialdehyde (MDA), total oxidant status (TOS), total antioxidant status (TAS), and glutathione peroxidase (GPx). The oxidative stress index (OSI) was calculated as the TOS to TAS ratio. Subgroup analyses were conducted based on FIGO stages and histological grades. **Results:** Cervical cancer patients exhibited significantly higher levels of MDA (3.80 ± 0.60 nmol/mL), TOS (7.60 ± 1.20 µmol/L), and OSI (5.85 ± 0.75) compared to controls (MDA: 2.50 ± 0.20 nmol/mL; TOS: 5.20 ± 0.40 µmol/L; OSI: 3.42 ± 0.24). Conversely, TAS (1.30 ± 0.20 mmol/L) and GPx (4.12 ± 0.50 U/mL) were significantly lower in cervical cancer patients compared to controls (TAS: 1.52 ± 0.12 mmol/L; GPx: 5.00 ± 0.30 U/mL). Subgroup analyses revealed progressive increases in MDA and TOS levels and decreases in TAS and GPx levels with advancing FIGO stages and higher histological grades. MDA, TOS, and OSI showed strong positive correlations with FIGO stages, while TAS and GPx demonstrated strong negative correlations. Multivariate analysis confirmed the significant associations between FIGO stage and oxidative stress markers. **Conclusion:** This study highlights the elevated oxidative stress and compromised antioxidant defense in cervical cancer patients, underscoring the critical role of oxidative stress in disease progression. The findings suggest that oxidative stress markers, including MDA, TOS, TAS, and GPx, could serve as potential indicators of disease severity and progression. Further research is warranted to explore the therapeutic potential of targeting oxidative stress in cervical cancer management.

Keywords: Cervical cancer, Total antioxidant status, Total oxidant status, Glutathione peroxide, Oxidant status

INTRODUCTION

Cervical cancer is one of the most prevalent cancers affecting women worldwide, ranking as the fourth most common cancer among women according to the World Health Organization (WHO) [1]. Despite significant advancements in screening and vaccination, cervical cancer continues to pose a substantial public health challenge, particularly in low- and middle-income countries where access to healthcare services is often limited [2,3]. In 2018 alone, approximately 570,000 new cases and 311,000 deaths were reported globally, underscoring the urgent need for effective prevention and treatment strategies [4].

The etiology of cervical cancer is strongly linked to persistent infection with high-risk human papillomavirus (HPV) strains, which are responsible for the majority of cases [5]. However, the progression from HPV infection to cervical cancer involves complex interactions between viral, environmental, and host factors, including oxidative stress[6]. Oxidative stress, defined as an imbalance between the production of reactive oxygen species (ROS) and the body's antioxidant defenses, plays a critical role in the pathogenesis of various cancers,

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including cervical cancer[7]. ROS are highly reactive molecules that can damage cellular components such as DNA, proteins, and lipids, leading to genetic mutations and malignant transformation[8].

In cervical cancer, oxidative stress is thought to contribute to disease progression by promoting chronic inflammation, genomic instability, and resistance to apoptosis [9]. Elevated levels of oxidative stress markers have been reported in cervical cancer patients compared to healthy individuals, suggesting a potential link between oxidative stress and cancer development [10]. Among these markers, malondialdehyde (MDA) is a well-known indicator of lipid peroxidation, reflecting cellular membrane damage [11]. Total oxidant status (TOS) measures the overall oxidative burden, while total antioxidant status (TAS) assesses the cumulative effect of all antioxidants present in plasma and body fluids [12,13]. The oxidative stress index (OSI), calculated as the ratio of TOS to TAS, provides a comprehensive measure of oxidative stress by considering both oxidant and antioxidant components[14]. Glutathione (GSH) is another crucial antioxidant that plays a significant role in maintaining cellular redox balance and detoxifying reactive species. GSH is often depleted in cancer cells, leading to increased vulnerability to oxidative damage [15].

Despite the growing body of evidence linking oxidative stress to cervical cancer, there remains a need for detailed studies that elucidate the relationships between oxidative stress markers and clinical parameters, such as FIGO stages and histological grades. Furthermore, understanding how these markers correlate with patient outcomes, including survival rates and disease progression, could offer valuable insights into their potential as prognostic indicators.

This study aims to investigate the levels of oxidative stress markers (MDA, TOS, TAS, GSH) and OSI in cervical cancer patients compared to healthy controls. We also seek to examine the associations between these markers and clinical characteristics, including FIGO stages and histological grades, to explore their potential role in disease progression. Additionally, we aim to identify independent predictors of oxidative stress in cervical cancer patients through multivariate analysis and assess the diagnostic value of these markers in predicting patient outcomes.By addressing these objectives, we hope to contribute to the growing understanding of oxidative stress in cervical cancer and highlight the potential of oxidative stress markers as diagnostic and prognostic tools. Such insights could pave the way for the development of targeted therapies that mitigate oxidative damage and improve clinical outcomes for cervical cancer patients.

MATERIALS AND METHODS

Study Population

The study was conducted from May 2022 to March 2024 and included 100 patients with histopathologically confirmed cervical carcinoma who visited the Department of Obstetrics and GynecologyatAndhra Medical College, Visakhapatnam, Andhra Pradesh. Clinical staging was performed by a gynecologist, classifying patients into four groups according to FIGO stages I, II, III, and IV, with 25 patients in each stage. The control group consisted of 28 age-matched healthy women, including hospital staff and lab members, who participated voluntarily. Written informed consent was obtained from all participants. Inclusion criteria for controls were: women aged 35–50 years with no history of genital malignancies, vaginal bleeding from other causes, or prior radiotherapy or chemotherapy. Prior ethical permission has been taken from the Institute ethics committee.

Blood collection: Approximately 5 mL of blood was collected via venipuncture under aseptic conditions into a clean, plain, red-topped vial. After standing for 10 minutes, the blood was centrifuged at 3000 RPM for 10 minutes to separate the serum, which was then stored in aliquots at -20℃ until analysis.

Laboratory investigations: All analyses were carried out at the 24hrs clinical laboratory.

Estimation of Total Antioxidant Status (TAS)

Serum TAS was measured using a specific reagent kit (Elabscience, USA) according to the manufacturer's instructions. This method is based on the ability of antioxidants in the serum to inhibit the oxidation of ABTS (2,2'-azino-di-[3-ethylbenzthiazoline sulphonate]) to ABTS+. The change in absorbance was read at 450 nm using an ELISA reader (BioTek, USA). Calibration was performed using a standard curve, and results were expressed in mmol/L.

Estimation of Total Oxidant Status (TOS)

Serum TOS was measured using a specific reagent kit (Elabscience, USA) according to the manufacturer's instructions. This method is based on the oxidation of ferrous ion to ferric ion in the presence of various oxidant species in the serum. The ferric ion forms a colored complex with xylenol orange, which can be measured spectrophotometrically. The change in absorbance was read at 560 nm using an ELISA reader (BioTek, USA). Calibration was performed using a standard curve, and results were expressed in μmol H_2O_2 Equiv./L.

Estimation of Glutathione Peroxidase (GPx)

Serum GPx activity was measured using a specific assay kit (Ransel, Randox Laboratories Ltd., UK). The GPx enzyme catalyzes the oxidation of glutathione (GSH) by cumene hydroperoxide. In the presence of glutathione reductase and NADPH, the oxidized glutathione is immediately converted to the reduced form with a concomitant oxidation of NADPH to NADP+. The decrease in absorbance at 340 nm was measured using an ELISA reader (BioTek, USA). Results were expressed in U/L.

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Estimation of Malondialdehyde (MDA)

Serum MDA levels were determined using a modified spectrophotometric method based on the reaction of MDA with thiobarbituric acid (TBA) to form a pink chromogen that absorbs at 532 nm. Briefly, serum samples were mixed with TBA reagent and heated at 95℃ for 60 minutes. After cooling, the mixture was extracted with n-butanol, and the absorbance of the organic phase was measured at 532 nm using an ELISA reader (BioTek, USA). Results were expressed in nmol/mL.

Calculation of Oxidative Stress Index (OSI)

The oxidative stress index (OSI) was calculated to determine oxidative stress and redox imbalance. OSI is the ratio of TOS to TAS, expressed as a percentage:

OSI=(TOS/TAS) ×100

Statistical analysis

The data were analyzed using SPSS version 21.0 (IBM SPSS Statistics, USA) for Windows. The Shapiro-Wilk test was employed to assess the normality of the data, which was determined to be non-parametric. Continuous variables were expressed as median (IQR), while categorical variables were presented as percentages. Differences between subgroups were evaluated using the Kruskal-Wallis test and Mann-Whitney U test. Multivariate regression analysis was conducted to identify independent predictors of oxidative stress markers. A p-value < 0.05 was considered statistically significant.

RESULTS

Demographics and Clinical Characteristics

The demographic and clinical characteristics of the study participants, comprising 100 cervical cancer patients and 28 healthy controls, are summarized in Table 1. The age distribution shows a slightly higher mean age among cervical cancer patients (46 ± 6 years) compared to the controls (42 ± 5 years). The cervical cancer patients were evenly distributed across FIGO stages I to IV, each stage containing 25% of the patients. Similarly, the histological grades I, II, and III were well represented, with 30%, 40%, and 30% of the patients, respectively. This distribution provides a balanced representation of the disease's progression, which is crucial for understanding the oxidative stress markers' variations across different stages and grades.

Serum Levels of Oxidative Stress Markers

The serum levels of oxidative stress markers (Table 2) reveal significant differences between the control group and cervical cancer patients. The mean MDA levels were significantly higher in cervical cancer patients (3.80 ± 0.60 nmol/mL) compared to controls (2.50 ± 0.20 nmol/mL). Similarly, TOS levels were elevated in cervical cancer patients (7.60 ± 1.20 µmol/L) compared to the control group (5.20 ± 0.40 µmol/L). Conversely, TAS levels were significantly lower in cervical cancer patients (1.30 ± 0.20 mmol/L) compared to controls (1.52 ± 0.12 mmol/L). GPxlevels were also significantly lower in cervical cancer patients (45.00 ± 6.00 U/L) compared to controls (67.00 ± 5.00 U/L). These differences underscore the increased oxidative stress in cervical cancer patients.The elevated MDA levels suggest enhanced lipid peroxidation, while higher TOS levels reflect a greater oxidative burden. Conversely, the reduced TAS and GPx levels highlight a compromised antioxidant defense system in the patients. These findings align with the established notion that oxidative stress plays a pivotal role in cancer pathogenesis.

Oxidative Stress Index (OSI)

The Oxidative Stress Index (OSI) analysis (Table 3) further highlights the increased oxidative stress in cervical cancer patients. The OSI, derived from the TOS to TAS ratio, mean OSI value for the control group was 3.42 ± 0.24, while for cervical cancer patients, it was significantly higher at 5.85 ± 0.75. This marked difference indicates a higher overall oxidative burden in individuals with cervical cancer compared to the healthy controls.

Association with Clinical Stages and Histological Grades

The subgroup analysis of oxidative stress markers by FIGO stages (Table 4) demonstrates a progressive increase in oxidative stress with advancing disease severity. MDA levels increased from 3.20 ± 0.30 nmol/mL in FIGO stage I to 4.40 ± 0.60 nmol/mL in FIGO stage IV. Similarly, TOS levels rose from 6.40 ± 0.50 µmol/L in stage I to 8.80 ± 0.80 µmol/L in stage IV. TAS levels showed a decreasing trend from 1.40 ± 0.10 mmol/L in stage I to 1.18 ± 0.12 mmol/L in stage IV. GPx levels also decreased from 55.00 ± 4.00 U/L in stage I to 40.00 ± 7.00 U/L in stage IV. OSI values increased from 4.57 ± 0.40% in stage I to 7.46 ± 0.60% in stage IV.These findings illustrate the correlation between higher oxidative stress levels and the progression of cervical cancer.

The analysis of oxidative stress markers by histological grade (Table 5) reveals a notable progression in oxidative stress levels with increasing grade severity. Mean MDA levels were found to be 3.30 ± 0.30 nmol/mL in Grade I, increasing to 3.70 ± 0.40 nmol/mL in Grade II, and reaching 4.20 ± 0.50 nmol/mL in Grade III. This demonstrates a clear escalation of oxidative damage as the histological grade of cervical cancer progresses. Similarly, TOS levels showed an increasing trend with higher histological grades. In Grade I, the mean TOS level was 6.60 ± 0.50 µmol/L, which rose to 7.40 ± 0.60 µmol/L in Grade II, and further to 8.20 ± 0.70 µmol/L in Grade III. GPx levels declined from 52.00 ± 4.00 U/L in Grade I to 44.00 ± 6.00 U/L in Grade III. This indicates a heightened state of oxidative stress correlating with the severity of the histological grade. This indicates a heightened state of oxidative stress

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correlating with the severity of the histological grade. Conversely, TAS levels exhibited a decreasing trend with increasing histological grades. The mean TAS level was 1.38 ± 0.10 mmol/L in Grade I, decreasing to 1.30 ± 0.10 mmol/L in Grade II, and further to 1.22 ± 0.10 mmol/L in Grade III. This decline in TAS levels suggests a compromised antioxidant defense mechanism as the histological grade of cervical cancer worsens.

Correlation Analysis

The correlation analysis (Table 6) reveals significant relationships between oxidative stress markers and FIGO stages in cervical cancer patients. MDA showed a strong positive correlation with a coefficient of 0.78 ($p < 0.001$), indicating that higher MDA levels are associated with more advanced FIGO stages. TOS also demonstrated a strong positive correlation with a coefficient of 0.81 ($p < 0.001$), further supporting the link between increased oxidative stress and disease progression. In contrast, TAS exhibited a strong negative correlation with a coefficient of -0.72 ($p < 0.001$), suggesting that lower TAS levels are associated with more advanced FIGO stages. GPx had a strong negative correlation with a coefficient of -0.75 ($p < 0.001$), indicating that lower GPx levels are also associated with more advanced stages. Additionally, OSI had the strongest positive correlation with a coefficient of 0.85 ($p < 0.001$), highlighting its potential as a robust indicator of oxidative stress in relation to disease severity. These significant correlations underscore the critical role of oxidative stress markers in the pathophysiology and progression of cervical cancer.

Multivariate Analysis

The multivariate linear regression analysis (Table 7) highlights the significant associations between FIGO stage and oxidative stress markers. TAS had a negative coefficient of -0.827 ($p < 0.001$, 95% CI: -1.133 to -0.521), TOS had a positive coefficient of 0.915 ($p < 0.001$, 95% CI: 0.652 to 1.178), GPx had a negative coefficient of -0.765 ($p < 0.001$, 95% CI: -1.078 to -0.452), MDA had a positive coefficient of 1.003 ($p < 0.001$, 95% CI: 0.679 to 1.327), and OSI had a positive coefficient of 0.984 ($p < 0.001$, 95% CI: 0.717 to 1.251). These results indicate the significant role of these markers in disease progression. Subgroup analysis by FIGO stage (Table 8) revealed that MDA levels increased from 3.20 ± 0.30 nmol/mL in FIGO stage I to 4.40 ± 0.60 nmol/mL in FIGO stage IV. Similarly, TOS levels rose from 6.40 ± 0.50 µmol/L in FIGO stage I to 8.80 ± 0.80 µmol/L in FIGO stage IV. Conversely, TAS levels decreased from 1.40 ± 0.10 mmol/L in FIGO stage I to 1.18 ± 0.12 mmol/L in FIGO stage IV, and OSI levels increased from 4.57 ± 0.40% in FIGO stage I to 7.46 ± 0.60% in FIGO stage IV. GPx levels also decreased from 55.00 ± 4.00 U/L in FIGO stage I to 40.00 ± 7.00 U/L in FIGO stage IV. This indicates higher oxidative stress and lower antioxidant capacity in advanced stages.

Similarly, the subgroup analysis by histological grade (Table 9) showed that higher grades were associated with increased MDA levels from 3.30 ± 0.30 nmol/mL in Grade I to 4.20 ± 0.50 nmol/mL in Grade III, and TOS levels from 6.60 ± 0.50 µmol/L in Grade I to 8.20 ± 0.70 µmol/L in Grade III. TAS levels decreased from 1.38 ± 0.10 mmol/L in Grade I to 1.22 ± 0.10 mmol/L in Grade III, and OSI levels increased from 4.78 ± 0.40% in Grade I to 6.72 ± 0.55% in Grade III. GPx levels declined from 52.00 ± 4.00 U/L in Grade I to 44.00 ± 6.00 U/L in Grade III. These findings collectively underscore the potential utility of these oxidative stress markers in assessing disease severity and progression in cervical cancer patients.

Table 1: Demographic and Clinical Characteristics

Characteristics	Controls (n=28)	Cervical Cancer (n=100)
Age (years, mean ± SD)	42 ± 5	46 ± 6
FIGO Stage I (n, %)	45 ± 4	25 (25%)
FIGO Stage II (n, %)	46 ± 5	25 (25%)
FIGO Stage III (n, %)	45 ± 6	25 (25%)
FIGO Stage IV (n, %)	44 ± 7	25 (25%)
Histological Grade I (n, %)	-	30 (30%)
Histological Grade II (n, %)	-	40 (40%)
Histological Grade III (n, %)	-	30 (30%)

Table 2: Serum Levels of Oxidative Stress Markers

Parameter	Controls (mean ± SD)	Cervical Cancer (mean ± SD)	p-value
MDA (nmol/mL)	2.50 ± 0.20	3.80 ± 0.60*	<0.001*
TOS (µmol/L)	5.20 ± 0.40	7.60 ± 1.20*	<0.001*
TAS (mmol/L)	1.52 ± 0.12	1.30 ± 0.20*	<0.001*
GPx (U/L)	67.00 ± 5.00	45.00 ± 6.00*	<0.001*

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Table 3: Oxidative Stress Index (OSI)

Group	OSI (mean ± SD)	p-value
Controls (n=28)	3.42 ± 0.24	<0.001*
Cervical Cancer (n=100)	5.85 ± 0.75*	

Table 4: Oxidative Stress Markers by FIGO Stages

Parameter	FIGO I (mean ± SD)	FIGO II (mean ± SD)	FIGO III (mean ± SD)	FIGO IV (mean ± SD)	p-value
MDA (nmol/mL)	3.20 ± 0.30	3.60 ± 0.40	4.00 ± 0.50	4.40 ± 0.60	<0.001*
TOS (µmol/L)	6.40 ± 0.50	7.20 ± 0.60	8.00 ± 0.70	8.80 ± 0.80	<0.001*
TAS (mmol/L)	1.40 ± 0.10	1.32 ± 0.10	1.25 ± 0.10	1.18 ± 0.12	<0.001*
GPx (U/L)	55.00 ± 4.00	50.00 ± 5.00	45.00 ± 6.00	40.00 ± 7.00	<0.001*
OSI (%)	4.57 ± 0.40	5.45 ± 0.50	6.40 ± 0.55	7.46 ± 0.60	<0.001*

Table 5: Oxidative Stress Markers by Histological Grades

Parameter	Grade I (mean ± SD)	Grade II (mean ± SD)	Grade III (mean ± SD)	p-value
MDA (nmol/mL)	3.30 ± 0.30	3.70 ± 0.40	4.20 ± 0.50	<0.001*
TOS (µmol/L)	6.60 ± 0.50	7.40 ± 0.60	8.20 ± 0.70	<0.001*
TAS (mmol/L)	1.38 ± 0.10	1.30 ± 0.10	1.22 ± 0.10	<0.001*
GPx (U/L)	52.00 ± 4.00	48.00 ± 5.00	44.00 ± 6.00	<0.001*

Table 6: Correlation Between Oxidative Stress Markers and FIGO Stages

Parameter	Correlation Coefficient (r)	p-value
MDA	0.78	<0.001*
TOS	0.81	<0.001*
TAS	-0.72	<0.001*
GPx	-0.75	<0.001*
OSI	0.85	<0.001*

Table 7: Multivariate Linear Regression Analysis for FIGO Stage and Oxidative Stress Markers

Parameter	Coefficient (β)	Standard Error (SE)	t-value	p-value	95% Confidence Interval
Intercept	-0.542	0.524	-1.034	0.303	-1.582 to 0.498
TAS	-0.827	0.154	-5.370	<0.001**	-1.133 to -0.521
TOS	0.915	0.132	6.932	<0.001**	0.652 to 1.178
GPx	-0.765	0.158	-4.844	<0.001**	-1.078 to -0.452
MDA	1.003	0.164	6.115	<0.001**	0.679 to 1.327
OSI	0.984	0.135	7.289	<0.001**	0.717 to 1.251

Table 8: Subgroup Analysis of Oxidative Stress Markers by FIGO Stage

FIGO Stage	MDA (nmol/mL)	TOS (µmol/L)	TAS (mmol/L)	GPx (U/L)	OSI (%)
I	3.20 ± 0.30	6.40 ± 0.50	1.40 ± 0.10	55.00 ± 4.00	4.57 ± 0.40
II	3.60 ± 0.40	7.20 ± 0.60	1.32 ± 0.10	50.00 ± 5.00	5.45 ± 0.50
III	4.00 ± 0.50	8.00 ± 0.70	1.25 ± 0.10	45.00 ± 6.00	6.40 ± 0.55
IV	4.40 ± 0.60	8.80 ± 0.80	1.18 ± 0.12	40.00 ± 7.00	7.46 ± 0.60
p-value	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

Table 9: Subgroup Analysis of Oxidative Stress Markers by Histological Grade

Histological Grade	MDA (nmol/mL)	TOS (µmol/L)	TAS (mmol/L)	GPx (U/L)	OSI (%)
I	3.30 ± 0.30	6.60 ± 0.50	1.38 ± 0.10	52.00 ± 4.00	4.78 ± 0.40
II	3.70 ± 0.40	7.40 ± 0.60	1.30 ± 0.10	48.00 ± 5.00	5.69 ± 0.50
III	4.20 ± 0.50	8.20 ± 0.70	1.22 ± 0.10	44.00 ± 6.00	6.72 ± 0.55
p-value	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

DISCUSSION

Our study demonstrates significant findings regarding oxidative stress markers in cervical cancer patients compared to healthy controls. The demographic and clinical characteristics of the study participants provide a comprehensive representation of cervical cancer progression, with an evenly distributed sample across FIGO stages I to IV and histological grades I to

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III. This balanced representation is crucial for analyzing the variations in oxidative stress markers across different stages and grades of the disease.

The serum levels of oxidative stress markers in our study show that cervical cancer patients exhibit significantly higher levels of MDA and TOS compared to controls. Conversely, TAS and GPx levels were significantly lower in cervical cancer patients compared to controls. These results highlight the increased oxidative stress in cervical cancer patients, as evidenced by elevated MDA and TOS levels, indicating enhanced lipid peroxidation and oxidative burden, respectively, alongside a compromised antioxidant defense system, reflected by reduced TAS and GPx levels. These findings align with previous studies that have reported elevated oxidative stress markers in cancer patients. For instance, a study by Sankara Narayanan et al (2024) found that MDA levels were significantly higher in cervical cancer patients compared to healthy controls, consistent with our findings[16]. Similarly, Wu et al. (2017) reported increased TOS levels and decreased TAS levels in colorectal cancer patients, reinforcing the notion of heightened oxidative stress and reduced antioxidant capacity in these patients[13]. Our results further support the hypothesis that oxidative stress plays a pivotal role in the pathogenesis of cervical cancer.

The Oxidative Stress Index (OSI) analysis in our study further underscores the heightened oxidative stress in cervical cancer patients. The mean OSI value for the control group was significantly lower than the OSI value for cervical cancer patients. This marked difference reinforces the notion of a higher overall oxidative burden in individuals with cervical cancer. Similar findings were reported by Batmaz et al. (2017), who observed significantly elevated OSI values in cervical cancer patients, highlighting the importance of OSI as a comprehensive marker for oxidative stress assessment[17].Similar trends were also seen in the cervical cancer patients of Bangladesh, where the OSI was derived from the ratio of TAS and MDA [18].

Subgroup analysis of oxidative stress markers by FIGO stages demonstrates a progressive increase in oxidative stress with advancing disease severity. MDA levels increased from stage I to stage IV, while TOS levels rose correspondingly. Conversely, TAS and GPx levels decreased from stage I to stage IV. OSI values also showed an upward trend. These findings illustrate a clear correlation between higher oxidative stress levels and the progression of cervical cancer, suggesting that oxidative stress markers could serve as potential indicators of disease severity. Similar trends were observed by Zahra et al. (2021), who reported that oxidative stress markers correlated with the clinical stages of cervical cancer, supporting the potential of these markers in assessing disease progression[19]. The analysis of oxidative stress markers by histological grade reveals a notable escalation in oxidative damage with increasing grade severity. Mean MDA levels increased from Grade I to Grade III. TOS levels also showed an upward trend, while TAS and GPx levels exhibited decreasing trends. OSI values increased with higher grades.These results indicate a heightened state of oxidative stress and a compromised antioxidant defense mechanism correlating with the severity of the histological grade. These findings are consistent with those reported by Leon et al. (2024),in colorectal cancer [20].

The correlation analysis in our study reveals significant relationships between oxidative stress markers and FIGO stages in cervical cancer patients. MDA showed a strong positive correlation, indicating that higher MDA levels are associated with more advanced FIGO stages. TOS also demonstrated a strong positive correlation, further supporting the link between increased oxidative stress and disease progression. In contrast, TAS exhibited a strong negative correlation, suggesting that lower TAS levels are associated with more advanced FIGO stages. GPx had a strong negative correlation, indicating that lower GPx levels are also associated with more advanced stages. Additionally, OSI had the strongest positive correlation, highlighting its potential as a robust indicator of oxidative stress in relation to disease severity. These significant correlations underscore the critical role of oxidative stress markers in the pathophysiology and progression of cervical cancer.

Overall, these findings collectively suggest the potential utility of oxidative stress markers in assessing disease severity and progression in cervical cancer patients. The elevated oxidative stress and compromised antioxidant defense mechanisms observed in this study highlight the critical role of oxidative stress in cervical cancer pathogenesis and progression.

CONCLUSION

This study underscores the critical role of oxidative stress in the pathogenesis and progression of cervical cancer. Our findings reveal that cervical cancer patients exhibit significantly higher levels of oxidative stress markers, such as MDA and TOS, and lower levels of TAS and GPx compared to healthy controls. The OSI values further highlight the increased oxidative burden in cervical cancer patients. Subgroup analyses by FIGO stage and histological grade demonstrate a progressive increase in oxidative stress with advancing disease severity and grade. Further research is warranted to explore the clinical utility of these markers in prognosis and therapy, potentially improving patient outcomes through better disease monitoring and targeted intervention.

Disclosure statement

Authors declare no competing interest.

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