ORIGINAL RESEARCH

Comparative Histopathological Analysis of Ocular and Uterine Tissues in Women with Systemic Hypertension

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ABSTRACT

Aim: The study aimed to compare the histopathological changes in ocular and uterine tissues in women with systemic hypertension, focusing on vascular and stromal alterations, to elucidate organ-specific responses to prolonged hypertensive stress. **Materials and Methods:** This retrospective study included 120 hypertensive women aged 40–65 years, divided into two groups: Group A (ocular tissues, n = 60) and Group B (uterine tissues, n = 60). Tissue samples were analyzed for vascular changes (endothelial thickening, intimal hyperplasia, hyalinization) and stromal alterations using hematoxylin and eosin staining. Quantitative and qualitative histopathological features were assessed, and logistic regression analysis identified predictors of stromal alterations. Statistical significance was set at $p< 0.05$. **Results:** The baseline characteristics were comparable between the groups. Endothelial thickening was observed in 75.00% of ocular tissues and 66.67% of uterine tissues ($p = 0.33$), while intimal hyperplasia was more prevalent in ocular tissues (83.33% vs. 70.00%; $p = 0.08$). Stromal alterations were significantly more frequent in uterine tissues (80.00% vs. 53.33%; $p = 0.004$), with higher stromal fibrosis scores (6.80 ± 1.70 vs. 4.20 ± 1.30; $p< 0.001$). Vessel wall thickness was also significantly greater in uterine tissues (15.10 ± 3.20 µm vs. 12.30 ± 2.40 µm; $p< 0.001$). Logistic regression identified duration of hypertension (OR: 1.12, $p< 0.001$), vessel wall thickness (OR: 1.25, $p< 0.001$), and stromal fibrosis score (OR: 1.30, $p< 0.001$) as key predictors of stromal alterations. **Conclusion:** The study revealed significant differences in histopathological changes between ocular and uterine tissues in hypertensive women. While vascular changes were evident in both tissues, uterine tissues demonstrated more extensive stromal alterations and fibrosis. These findings underscore the organ-specific impact of hypertension, emphasizing the need for targeted management strategies.

Keywords: Systemic hypertension, Histopathology, Ocular tissues, Uterine tissues, Vascular remodeling

INTRODUCTION

Systemic hypertension, a chronic medical condition characterized by persistently elevated blood pressure, is one of the leading risk factors for cardiovascular diseases and organ dysfunction worldwide. Despite being a systemic disease, hypertension exerts its effects at the tissue level, resulting in complex pathological changes that vary based on the structure and function of the affected organ. Among the most susceptible organs are the eyes and uterus, both of which are highly vascularized and demonstrate unique responses to hypertensive injury. This study focuses on the comparative histopathological analysis of ocular and uterine tissues in women with systemic hypertension, aiming to elucidate the similarities and differences in their responses to prolonged hypertensive stress.[1]The pathophysiological mechanisms of hypertension involve a combination of

vascular dysfunction, oxidative stress, and inflammatory processes. These factors collectively contribute to structural and functional remodeling in various tissues, with alterations in vascular walls, increased extracellular matrix deposition, and ischemic damage being hallmark features. While these changes are well-documented in certain organs like the heart and kidneys, there is limited research comparing the histopathological effects of hypertension on the ocular and uterine tissues. Such a comparison is critical given the unique physiological roles of these organs and their differential susceptibilities to hypertensive damage.[2]Ocular tissues are particularly vulnerable to hypertension-induced damage due to the small caliber of retinal vessels and their role in maintaining the eye's microcirculation. Hypertension in the ocular vasculature can lead to structural changes such as endothelial thickening, intimal hyperplasia, and hyalinization, which may compromise blood flow and result in visual impairment. The retina, choroid, and optic nerve are often sites of significant histopathological changes in systemic hypertension. Conditions such as hypertensive retinopathy and choroidopathy highlight the direct impact of elevated blood pressure on ocular health.[3]In contrast, uterine tissues are subject to a dynamic vascular environment influenced not only by systemic hypertension but also by hormonal fluctuations. The uterus, with its extensive vasculature and stromal network, plays a vital role in reproductive health and pregnancy. Hypertension can lead to vascular remodeling and stromal fibrosis in uterine tissues, impairing uteroplacental circulation and contributing to complications such as preeclampsia, fetal growth restriction, and infertility. Moreover, the hormonal regulation of uterine function adds another layer of complexity to its histopathological response to hypertension.[4]Although both ocular and uterine tissues are affected by systemic hypertension, the patterns and degrees of histopathological changes may vary due to differences in their anatomical structures and physiological demands. The ocular vasculature operates under low perfusion pressure and is shielded from systemic fluctuations by the blood-retinal barrier, whereas the uterine vasculature undergoes cyclic changes in response to hormonal signals. These distinctions suggest that hypertension may elicit organ-specific responses, emphasizing the need for comparative analyses to better understand these variations.[5]Furthermore, understanding the histopathological changes in these tissues could have significant clinical implications. Ocular manifestations of hypertension, often detected through non-invasive retinal examinations, could serve as biomarkers for systemic vascular changes. Similarly, identifying the impact of hypertension on uterine tissues could inform strategies to manage reproductive complications associated with this condition. Comparative studies of this nature are essential for bridging the gap between systemic disease processes and organ-specific pathology.[6,7]This study aims to explore and compare the histopathological features of ocular and uterine tissues in women with systemic hypertension. By analyzing key parameters such as vascular remodeling, stromal alterations, and ischemic damage, the research seeks to identify patterns of tissue-specific changes and their potential correlations with clinical characteristics. Additionally, it investigates predictors of stromal alterations and vascular changes to better understand the underlying mechanisms driving these pathological processes.The findings of this study could contribute to the growing body of knowledge on the systemic effects of hypertension and highlight the importance of tailoring interventions to address organ-specific complications. Furthermore, the insights gained could pave the way for future research into therapeutic approaches that target the shared and distinct mechanisms of hypertensive damage in ocular and uterine tissues.

MATERIALS AND METHODS

This retrospective study included 120 female patients diagnosed with systemic hypertension, selected from hospital records over a two-year period. The patients, aged 40–65 years, were divided into two groups based on the availability of biopsy specimens from either ocular or uterine tissues. Group A comprised patients with ocular tissue samples obtained during ophthalmologic procedures, such as enucleation or biopsy, due to conditions unrelated to systemic hypertension, while Group B included patients with uterine tissue samples collected during hysterectomies performed for benign gynecological conditions. All patients had a documented history of systemic hypertension for a minimum of five years prior to tissue collection. Exclusion criteria included patients with coexisting systemic diseases, such as diabetes mellitus or autoimmune disorders, or those receiving immunosuppressive therapy.

Histopathological analysis was conducted on formalin-fixed, paraffin-embedded tissue sections stained with hematoxylin and eosin. Specific features evaluated included vascular changes, such as endothelial thickening, intimal hyperplasia, and hyalinization, as well as stromal alterations and evidence of ischemic damage. Each sample was reviewed independently by two experienced pathologists blinded to the clinical details to ensure unbiased evaluation.

Data were collected on patient demographics, duration of hypertension, and any history of antihypertensive treatment. Comparative analyses were performed to identify common and distinct histopathological findings between ocular and uterine tissues. Statistical analysis was carried out using appropriate software, with categorical variables expressed as frequencies and percentages, and continuous variables as means ± standard deviations. The chi-square test and Student's t-test were used to compare categorical and

continuous variables, respectively, with a significance threshold set at $p< 0.05$. Ethical approval was obtained from the institutional review board, and all procedures adhered to the Declaration of Helsinki guidelines.

RESULTS

The baseline characteristics of the two groups revealed no statistically significant differences, indicating comparability. The mean age was slightly higher in Group A (ocular tissues) at 54.20 ± 6.10 years compared to 53.80 ± 5.90 years in Group B (uterine tissues) ($p = 0.68$). Both groups had similar durations of hypertension, with averages of 8.70 ± 2.30 years in Group A and 8.50 ± 2.40 years in Group B ($p = 0.73$). The proportion of patients receiving antihypertensive treatment was comparable, with 80.00% in Group A and 76.67% in Group B ($p = 0.67$). Body mass index (BMI) values were also similar, with no significant difference between the groups (27.50 ± 3.20 vs. 28.10 ± 3.50; $p = 0.42$). Other parameters, including smoking history, family history of hypertension, systolic and diastolic blood pressures, serum cholesterol, and serum creatinine levels, showed no significant differences between the groups. This suggests that both cohorts were well-matched in terms of clinical and demographic profiles.

The histopathological analysis revealed variations in vascular and stromal changes between ocular and uterine tissues. Endothelial thickening was observed in 75.00% of ocular tissues and 66.67% of uterine tissues, with no significant difference ($p = 0.33$). Similarly, intimal hyperplasia was slightly more prevalent in ocular tissues (83.33%) compared to uterine tissues (70.00%), but the difference did not reach statistical significance ($p = 0.08$). Hyalinization was more common in uterine tissues (73.33%) than ocular tissues (63.33%), though this difference was also not significant ($p = 0.25$). Stromal alterations, however, were significantly more frequent in uterine tissues (80.00%) compared to ocular tissues (53.33%) ($p = 0.004$). Evidence of ischemic damage was noted in 46.67% of ocular tissues and 60.00% of uterine tissues, without a statistically significant difference ($p = 0.14$). These findings suggest that stromal changes are more prominent in uterine tissues among hypertensive patients.

Quantitative analysis of vascular and stromal changes highlighted significant differences between the two tissue types. Vessel wall thickness was significantly greater in uterine tissues (15.10 ± 3.20 μm) compared to ocular tissues (12.30 ± 2.40 μm) ($p< 0.001$). Similarly, the number of affected vessels was higher in uterine tissues (10.20 ± 2.10) than in ocular tissues (8.50 ± 1.80) ($p< 0.01$). Stromal fibrosis scores were markedly elevated in uterine tissues (6.80 ± 1.70) compared to ocular tissues (4.20 ± 1.30), indicating more extensive stromal alterations in the uterine samples ($p< 0.001$). These differences underscore the more pronounced vascular remodeling and fibrosis in uterine tissues, possibly due to differences in tissue-specific responses to systemic hypertension.

Regression analysis identified key predictors of stromal alterations. The duration of hypertension was a significant factor, with an odds ratio (OR) of 1.12 (95% CI: 1.05–1.18, $p< 0.001$), indicating that a longer history of hypertension increases the likelihood of stromal changes. Vessel wall thickness also emerged as a significant predictor (OR: 1.25, 95% CI: 1.15–1.35, $p< 0.001$), as did the number of affected vessels (OR: 1.18, 95% CI: 1.08–1.28, $p< 0.01$). Stromal fibrosis score was the strongest predictor, with an OR of 1.30 (95% CI: 1.20–1.40, $p< 0.001$), reflecting its direct correlation with the severity of hypertension-induced damage. Antihypertensive treatment did not significantly influence the likelihood of stromal alterations (OR: 0.85, $p = 0.24$), suggesting that other factors, such as tissue-specific susceptibility and duration of disease, play more critical roles.

Table 1: Demographic and Clinical Characteristics of Patients

Variable	Group A: Ocular Tissues (n = 60)	Group B: Uterine Tissues (n = 60)	p-value
Age (years, mean ± SD)	54.20 ± 6.10	53.80 ± 5.90	0.68
Duration of Hypertension (years)	8.70 ± 2.30	8.50 ± 2.40	0.73
Antihypertensive Treatment	48 (80.00%)	46 (76.67%)	0.67
Body Mass Index (BMI, kg/m²)	27.50 ± 3.20	28.10 ± 3.50	0.42
Smoking History	10 (16.67%)	12 (20.00%)	0.65
Family History of Hypertension	36 (60.00%)	34 (56.67%)	0.71
Systolic Blood Pressure (mmHg)	145.20 ± 10.50	148.30 ± 12.40	0.15
Diastolic Blood Pressure (mmHg)	92.10 ± 8.30	91.70 ± 9.10	0.81
Serum Cholesterol (mg/dL)	202.40 ± 15.30	198.20 ± 14.80	0.19
Serum Creatinine (mg/dL)	1.10 ± 0.15	1.08 ± 0.17	0.48

Table 2: Histopathological Features in Ocular and Uterine Tissues

Histopathological Feature	Group A: Ocular Tissues (n = 60)	Group B: Uterine Tissues (n = 60)	p-value
Endothelial Thickening	45 (75.00%)	40 (66.67%)	0.33

Intimal Hyperplasia	50 (83.33%)	42 (70.00%)	0.08
Hyalinization	38 (63.33%)	44 (73.33%)	0.25
Stromal Alterations	32 (53.33%)	48 (80.00%)	0.004**
Evidence of Ischemic Damage	28 (46.67%)	36 (60.00%)	0.14

Table 3: Comparative Vascular and Stromal Changes

Feature	Group A: Ocular Tissues (mean ± SD)	Group B: Uterine Tissues (mean ± SD)	p-value
Vessel Wall Thickness (μm)	12.30 ± 2.40	15.10 ± 3.20	<0.001**
Number of Affected Vessels	8.50 ± 1.80	10.20 ± 2.10	<0.01**
Stromal Fibrosis Score (0–10)	4.20 ± 1.30	6.80 ± 1.70	<0.001**

Table 4: Logistic Regression Analysis of Stromal Alterations and Hypertension Parameters

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Duration of Hypertension	1.12	1.05–1.18	<0.001**
Antihypertensive Treatment (Yes)	0.85	0.65–1.12	0.24
Vessel Wall Thickness	1.25	1.15–1.35	<0.001**
Number of Affected Vessels	1.18	1.08–1.28	<0.01**
Stromal Fibrosis Score	1.30	1.20–1.40	<0.001**

DISCUSSION

This study provides a comparative histopathological analysis of ocular and uterine tissues in women with systemic hypertension, highlighting significant differences in vascular and stromal alterations.The similarity in baseline characteristics, such as age, duration of hypertension, and antihypertensive treatment rates, between the two groups suggests that the observed histopathological differences are not confounded by these factors. Previous studies have also demonstrated that systemic hypertension contributes uniformly to vascular remodeling across tissues (Rizzoni et al., 2012).[8] However, variations in tissue-specific vascular structures may explain the more pronounced changes observed in uterine tissues in this study.Endothelial thickening and intimal hyperplasia were observed more frequently in ocular tissues (75.00% and 83.33%, respectively) compared to uterine tissues (66.67% and 70.00%, respectively). This aligns with research by Mulvany and Aalkjaer (1990), which reported that hypertension-induced vascular remodeling is often more evident in smaller vessels, such as those found in ocular tissues.[9] However, uterine tissues exhibited a higher prevalence of stromal alterations (80.00% vs. 53.33%, $p = 0.004$), consistent with findings from Gordijn et al. (2014), who noted that uterine vasculature and stroma are particularly susceptible to ischemic and fibrotic changes due to their high vascularity and hormonal responsiveness.[10]Hyalinization and ischemic damage were also more common in uterine tissues (73.33% and 60.00%, respectively) than ocular tissues (63.33% and 46.67%). These results align with the work of Dimitropoulos et al. (2011), who demonstrated that uterine tissues show greater susceptibility to fibrosis and ischemia under chronic hypertension, likely due to increased vascular demand during reproductive cycles.[11]Quantitative measures of vascular remodeling, including vessel wall thickness and the number of affected vessels, were significantly greater in uterine tissues (15.10 ± 3.20 μm and 10.20 ± 2.10, respectively) compared to ocular tissues (12.30 ± 2.40 μm and 8.50 ± 1.80, respectively). Similar findings were reported by Zhou et al. (2018), who noted that uterine vessels exhibit greater hypertrophic remodeling compared to ocular vessels due to their dynamic vascular nature.[12]Stromal fibrosis was significantly more pronounced in uterine tissues (6.80 ± 1.70 vs. 4.20 ± 1.30, $p< 0.001$). This aligns with studies by Khorram et al. (2010) and Zhou et al. (2018), which suggested that uterine stroma undergoes more extensive fibrosis due to chronic ischemia and hormonal fluctuations, exacerbated by systemic hypertension.[12,13]Regression analysis identified vessel wall thickness, duration of hypertension, and stromal fibrosis scores as significant predictors of stromal alterations. This supports previous findings by Intengan and Schiffrin (2001), who emphasized the role of long-term hypertension in driving vascular and stromal changes.14 Interestingly, antihypertensive treatment did not significantly reduce the likelihood of stromal alterations in this study, which aligns with findings by Barhoumi et al. (2011) suggesting that antihypertensive medications primarily target vascular tone rather than reversing structural remodeling.[15]This study adds to the growing body of evidence on tissue-specific effects of hypertension. The prevalence of stromal alterations in uterine tissues (80.00%) and its association with vessel wall thickness (OR: 1.25, $p< 0.001$) corroborates previous findings (Khorram et al., 2010).[13] Meanwhile, the higher frequency of vascular changes in ocular tissues (83.33%) supports earlier reports on the susceptibility of ocular vessels to hypertension-induced damage (Mulvany and Aalkjaer, 1990).[9] The novel aspect of this study lies in directly comparing these two tissue types, providing insights

into their differential responses to systemic hypertension.

CONCLUSION

This study highlights significant differences and similarities in the histopathological responses of ocular and uterine tissues to systemic hypertension. While vascular changes, such as endothelial thickening and intimal hyperplasia, were observed in both tissues, uterine tissues exhibited more pronounced stromal alterations and fibrosis. These findings emphasize the organ-specific impact of systemic hypertension, driven by differences in vascular architecture and physiological demands. Understanding these patterns can guide targeted interventions for managing hypertensive complications in vulnerable tissues and improve clinical outcomes.

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