MORPHOLOGICAL AND HISTOLOGICAL ALTERATIONS OF THE GASTRIC MUCOSA INDUCED BY EXPERIMENTAL ACUTE STRESS IN ANIMAL MODELS

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Annotation

This study investigates the profound morphological and histological changes in the gastric mucosa triggered by experimental acute stress. While the physiological responses to stress are well-documented, the precise microstructural alterations in the stomach require continuous exploration to develop targeted cytoprotective therapies. Using a Water Immersion Restraint Stress (WIRS) model on Wistar rats, we analyzed the gastric tissue through histological and morphometric techniques. The findings reveal significant mucosal degradation, including severe hyperemia, microvascular thrombosis, epithelial desquamation, and hemorrhagic erosions in the stress-subjected group compared to the control. The study underscores the critical role of ischemia and compromised mucosal microcirculation in the pathogenesis of stress-induced gastric lesions, emphasizing the need for prophylactic pharmacological interventions.

Key Words: experimental stress, gastric mucosa, morphological changes, Water Immersion Restraint Stress (WIRS), histology, ischemia, mucosal barrier, stress ulcers.

Introduction

The gastrointestinal tract is highly sensitive to external and internal stressors, with the stomach being one of the most vulnerable organs. Stress-induced gastric lesions, commonly referred to as stress ulcers, represent a significant clinical challenge, particularly in critically ill patients, trauma victims, and individuals suffering from severe psychological distress. The pathogenesis of these lesions is multifactorial, primarily involving a severe imbalance between aggressive factors (gastric acid, pepsin, oxidative stress) and defensive mechanisms (mucus-bicarbonate barrier,

prostaglandins, mucosal blood flow). Despite advancements in gastroenterology, understanding the exact sequential morphological disruptions at the cellular level during the acute phase of stress remains crucial. This study aims to evaluate the precise morphological and histological modifications in the structural organization of the gastric wall under acute experimental stress, providing a microanatomical basis for the development of future cytoprotective strategies.

Material and Methods

1. Experimental Animals

The study was conducted on adult male Wistar rats, weighing between 180–220 grams. The animals were housed under standard laboratory conditions (temperature 22±2°C, 12-hour light/dark cycle) and were acclimatized for one week prior to the experiment. They were randomly divided into two groups:

- **Group 1 (Control):** Intact rats not subjected to any stressogenic factors ($n=10$).
- **Group 2 (Experimental Stress):** Rats subjected to acute stress ($n=10$).

2. Stress Model

Acute stress was induced using the standard Water Immersion Restraint Stress (WIRS) method. After a 24-hour fasting period (with free access to water), the rats in Group 2 were immobilized in custom-designed restraint cages and immersed up to the xiphoid process in a water bath maintained at 23°C for exactly 6 hours.

3. Histological Preparation

Immediately following the stress exposure, the animals were euthanized under deep anesthesia. The stomachs were rapidly excised, opened along the greater curvature, gently rinsed with cold saline, and macroscopically examined for lesion scoring. Tissue samples were taken from the glandular portion of the stomach, fixed in 10% neutral buffered formalin for 24 hours, dehydrated in graded ethanol, and embedded in paraffin. Sections of 4–5 μm thickness were cut and stained with:

- **Hematoxylin and Eosin (H&E):** For general morphological assessment.
- **Periodic Acid-Schiff (PAS):** To evaluate the integrity of the mucosal glycoprotein (mucin) layer.

4. Morphometric Analysis

Microscopic evaluation was performed using a light microscope equipped with a digital imaging system. Measurements included mucosal thickness, the depth of erosions, and the state of the microcirculatory bed.

Results and Discussion

Macroscopic Findings

Macroscopic examination of the control group stomachs revealed a normal, pale pink mucosa with intact, continuous rugae. In contrast, the stomachs of the experimental stress group (Group 2) exhibited multiple, distinct pathological changes. These included pronounced hyperemia, mucosal edema, and the presence of scattered linear and punctate hemorrhagic lesions predominantly located in the glandular corpus of the stomach.

Microscopic and Morphological Alterations

Histological analysis of the control group demonstrated intact surface epithelium, tightly packed gastric glands, and a normal microvascular network within the lamina propria.

Conversely, the WIRS group displayed severe morphological disruptions:

- **Epithelial Damage:** Widespread desquamation of the surface mucous cells. The PAS staining revealed a significant depletion of the protective mucosal glycoprotein layer compared to the intense, continuous PAS-positive layer in the control group.
- **Microcirculatory Collapse:** The mucosal and submucosal layers showed severe vascular congestion, stasis of erythrocytes within capillaries, and micro-thrombosis.
- **Deep Tissue Injury:** Extensive areas of coagulative necrosis and hemorrhagic erosions penetrating down to the neck region of the gastric glands. Inflammatory cell infiltration (neutrophils and macrophages) was evident at the margins of the necrotic zones.
- **Morphometric Changes:** There was a statistically significant reduction in overall mucosal thickness in the stress group due to the loss of the apical epithelial layers.

Discussion

The profound morphological changes observed in this study align with the theory that stress primarily induces gastric damage through severe local ischemia. The cold and restraint stress triggers sympathetic nervous system overactivity, leading to extreme vasoconstriction of the splanchnic circulation. This ischemic environment deprives the gastric tissue of oxygen and nutrients, halting the production of protective mucus and bicarbonates. Subsequent reperfusion exacerbates the damage via the generation of reactive oxygen species (ROS), which rapidly destroy cell membranes through lipid peroxidation, culminating in the observed cellular necrosis and hemorrhagic erosions.

Conclusion and Recommendation

Conclusion

Acute experimental stress induces rapid and severe morphological degradation of the gastric mucosa. The pathogenesis is structurally characterized by the breakdown of the superficial mucous barrier, profound microvascular stasis, subsequent mucosal ischemia, and eventual cellular necrosis leading to hemorrhagic erosions. These findings visually and quantitatively confirm the high vulnerability of the gastric microcirculation to stressogenic factors.

Recommendation

Based on the morphological evidence of extreme oxidative and ischemic damage, it is highly recommended that future therapeutic protocols for stress-susceptible patients incorporate robust microvascular protectors and antioxidant agents. Further experimental studies should focus on testing the prophylactic efficacy of specific vasoprotective peptides and natural antioxidants in preserving the morphological integrity of the gastric wall before the onset of extreme stress.

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