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Examining the Biochemical and Toxicological Effects of Insulin Overdose in Rats: Insights from a Forensic Angle

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Abstract

Insulin overdose is a critical concern in forensic investigations due to its potential lethality and widespread availability. This mini-review explores the biochemical and toxicological effects of insulin overdose in rats, offering insights from a forensic perspective. By examining relevant literature, this article elucidates the mechanisms of insulin toxicity, including hypoglycemia, neurologic impairment, and cardiovascular complications. Additionally, it discusses forensic considerations such as postmortem findings, analytical techniques for insulin detection, and interpretation challenges in forensic pathology. Understanding the intricacies of insulin overdose in animal models provides valuable insights for forensic scientists and medical examiners in cases involving suspected insulin-related fatalities.

Keywords: Insulin overdose • Rats • Forensic investigations

Introduction

Insulin, a hormone crucial for glucose metabolism, is commonly misused for suicidal or homicidal purposes. Accidental overdoses also occur, especially in diabetic patients. The forensic investigation of insulin-related fatalities necessitates a comprehensive understanding of its biochemical and toxicological effects, particularly in animal models such as rats. This mini-review aims to synthesize current knowledge on insulin overdose in rats from a forensic standpoint.

Literature Review

Insulin overdose induces profound hypoglycemia, disrupting glucose homeostasis in rats. Excessive insulin promotes glucose uptake by peripheral tissues, depleting circulating glucose levels and impairing cerebral glucose supply. Hypoglycemia triggers a cascade of neuroendocrine responses, including catecholamine release, to counteract insulin's effects. However, sustained hypoglycemia leads to neuroglycopenia, causing neurological manifestations such as confusion, seizures, and coma in rat models [1].

Furthermore, insulin overdose alters lipid metabolism in rats, enhancing fatty acid synthesis and inhibiting lipolysis. This metabolic shift exacerbates hypoglycemia by depleting alternative energy sources, exacerbating cellular dysfunction and organ damage. Additionally, insulin's anabolic effects on protein metabolism may contribute to tissue injury and organ failure in rats following overdose [2].

Discussion

Beyond hypoglycemia, insulin overdose elicits toxicological effects on various organ systems in rat models. Neurologically, insulin-induced hypoglycemia impairs neuronal function, leading to cognitive deficits, motor impairment, and even neuronal death in severe cases. Cardiovascular complications, including arrhythmias, myocardial ischemia, and heart failure, may arise from insulin's hemodynamic effects and electrolyte imbalances in rats [3].

Moreover, insulin overdose exacerbates oxidative stress and inflammation in rats, contributing to multi-organ damage and systemic toxicity. Mitochondrial dysfunction, mediated by excessive insulin signaling, further amplifies cellular injury and apoptosis in vital organs such as the liver, kidneys, and pancreas. These toxicological alterations underlie the pathological manifestations observed in forensic examinations of insulin-related fatalities in rats [4].

In forensic investigations of suspected insulin overdose in rats, postmortem examinations play a pivotal role in elucidating the cause and manner of death. Macroscopic and microscopic findings, including brain edema, hepatic steatosis, and myocardial necrosis, provide valuable insights into the pathophysiological consequences of insulin toxicity [5].

Analytical techniques for detecting insulin in rat tissues and body fluids are indispensable for confirming overdose cases. Immunoassays, chromatography coupled with mass spectrometry, and enzymatic methods are commonly employed for insulin quantification in forensic toxicology laboratories. However, challenges such as insulin degradation and cross-reactivity with endogenous substances necessitate meticulous method validation and interpretation [6].

Conclusion

Insulin overdose in rats elicits complex biochemical and toxicological effects with significant forensic implications. Hypoglycemia-induced neurologic impairment, cardiovascular complications, and multi-organ toxicity underscore the severity of insulin toxicity in forensic pathology. Integrating knowledge of insulin pharmacology, animal models, and analytical techniques enhances the forensic investigation of suspected insulin-related fatalities. Future research should focus on elucidating the molecular mechanisms underlying insulin toxicity and refining analytical methods for accurate insulin quantification in forensic specimens. This mini-review underscores the importance of interdisciplinary collaboration between toxicologists, pathologists, and forensic scientists in unraveling the forensic mysteries surrounding insulin overdose in rats.

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Conflict of Interest

None.

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