Review article

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Traumatic adrenal injury in critical care: A review of current perspectives

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Abstract

Traumatic adrenal gland injuries, though uncommon, pose significant clinical challenges due to their association with numerous concomitant injuries and potential complications. This review synthesizes current knowledge on traumatic adrenal injuries, emphasizing their anatomical and epidemiological context, diagnostic modalities, and management strategies. Adrenal gland trauma often co-occurs with injuries to adjacent abdominal organs, typically manifesting with vague symptoms that complicate early detection and diagnosis. Advancements in imaging technologies, particularly computed tomography, have facilitated increased detection rates, highlighting the need for timely and accurate diagnostic approaches. The pathophysiological mechanisms remain partially understood, although three primary theories attempt to elucidate the mechanisms leading to injury. Treatment strategies are primarily conservative, escalating to surgical or interventional measures, such as transcatheter arterial embolization, when hemodynamic instability is evident. Despite the historical association of adrenal trauma with higher injury severity and mortality, recent evidence suggests that adrenal bleeding does not substantially increase mortality rates independently but rather highlights the role of associated injuries. This review underscores the importance of systematic follow-up post-management and calls for further research to establish comprehensive treatment protocols within the evolving landscape of trauma care.

Key words: Traumatic adrenal injury, diagnostic imaging, conservative management, computed tomography (CT), transcatheter arterial embolization (TAE), Injury Severity Score (ISS).

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Introduction

Traumatic adrenal gland injuries (AGI), although rare, present significant clinical concern due to their association with numerous concomitant injuries and potential complications. Typically co-occurring with trauma to adjacent abdominal organs, such adrenal injuries often manifest with non-specific symptoms that can delay diagnosis. (1,2) Such injuries can result in severe complications, including acute adrenal insufficiency and secondary infections, underscoring the importance of prompt diagnosis and effective management. Moreover, current literature indicates that patients with adrenal injuries have a higher mortality rate, with a significant risk of severe sequelae upon identification of such injuries. (3,4) Given this background, it is imperative to systematically review the incidence and ramifications of traumatic adrenal injuries to enhance patient care outcomes.

This review endeavors to comprehensively consoli-

date existing knowledge and recent research insights regarding traumatic adrenal injuries through a systematic exploration of pathophysiological mechanisms, clinical manifestations, diagnostic procedures, therapeutic strategies, and consequent complications. Such an overview aims to foster improved understanding and prognosis in managing these injuries.

Anatomy and anatomical location

The adrenal glands are diminutive retroperitoneal structures beneath the diaphragm and anchored to the kidneys. Specifically, the right adrenal gland, positioned more posteriorly than its left counterpart, assumes a pyramidal shape and is bounded anteriorly by the right hepatic lobe and inferior vena cava (IVC). (5) Conversely, the left gland, crescent-shaped, nestles amidst the stomach and pancreas and is more distantly located from the spinal column. The right adrenal vein's proximity to the spinal column renders it more vulnerable to contusions and edema, with literature predominantly describing injuries to the right gland. (5-7)

Epidemiology

Since Canton's seminal description in 1863, (8) advancements in diagnostic modalities have led to an increased detection of adrenal trauma. Whereas incidence rates in the 1990s were reported between 0.04% and 0.24%, recent advances have led to a notable increase, with figures ranging from 0.44% to 2.4%, paralleling the expanded use of whole-body computed tomography (CT) imaging in trauma assessments. (9,10) Additionally, autopsy studies demonstrate a higher incidence than previously captured by trauma databases, reporting rates between 7% and 26%. (11) These statistics underscore the actual prevalence of adrenal gland injuries in blunt trauma scenarios, suggesting their frequency has been historically underestimated.

Mechanisms of traumatic injury

While the precise pathophysiology remains partially understood, three main theories have been posited to elucidate adrenal trauma mechanisms. (12) The first theory proposes that compression of the inferior vena cava during abdominal impacts causes acutely elevated intra-adrenal venous pressures, accounting for the predominance of right-sided injuries. Indeed, studies indicate blunt adrenal injuries occur on the right in 72.8% of cases, with 19.9% on the left, and 7.3% bilaterally. (10) The heightened incidence on the right is attributed to the shorter right adrenal vein's direct connection to the inferior vena cava, which facilitates pressure transmission, and its anatomical position between the spine and liver, predisposing it to compressive forces. (13) The second theory involves glandular compression between the spine and adjacent solid organs, while the third suggests decelerative forces shear adrenal arterioles, causing injury. (12)

Associated organ injuries

Due to their anatomical positioning, adrenal traumas frequently coincide with injuries to surrounding organs. Liao et al. reported concomitant injuries in 93.5% of cases, with liver injuries (66.2%), rib fractures (48.1%), and renal injuries (42.9%) being prevalent. (14) Stawicki et al. corroborated these findings, noting liver involvement in 57.8% and rib fractures in 50.9% of cases. (3) Further, Panda et al. identified the liver (46.8%), spleen (21.3%), and kidneys (10.6%) as most commonly involved abdominal organs, alongside thoracic injuries (61.7%). (15) Given these associations, patients often present with Injury Severity Scores (ISS) exceeding 15, with Alsayali et al. noting such scores in 85% of cases. (7,9)

Clinical presentation

Clinical manifestations, including dull back pain, are often ambiguous and may be accompanied by laboratory indicators of hyper- or hypotension, leukocytosis, and minor electrolyte imbalances. (16) Symptoms are contingent upon the American Association for the Surgery of Trauma (AAST) classification of adrenal injury (**Table 1**). In the milieu of trauma, increased catecholamine secretion exacerbates arterial blood flow to the adrenals, risking hemorrhagic presentations. (17)

Diagnostic imaging modalities

Focused Assessment with Sonography in Trauma (FAST) is a prevalent tool in identifying AGI, particularly while assessing Morison's pouch or the splenorenal recess. However, the primary diagnostic modality remains abdominal CT scans, capable of detecting numerous lesions that FAST might miss due to concurrent multiple organ injuries. (18) While ultrasound can discern significant AGI, its efficacy is limited by gland size and examiner expertise. Contrast-enhanced computed tomography (CE-CT) stands as the preferred diagnostic standard, (19) revealing characteristic adrenal hematomas, hemorrhages, glandular swelling, and other trauma indicators. (20) Magnetic resonance imaging (MRI), although less common in emergencies, is valuable for follow-up, where hematomas exhibit specific muscle-relative signal intensities on T1 and T2-weighted images. (19)

Treatment approaches

Currently, no definitive management guidelines exist for adrenal injuries; treatment strategies largely reflect the severity of associated injuries rather than the adrenal trauma itself. Conservative management predominates, shifting to surgical or interventional interventions in cases of arterial hemorrhage coupled with hemodynamic instability. (14,21) Transcatheter arterial embolization (TAE) is increasingly employed for its noninvasive efficacy in managing adrenal trauma. (21) TAE for adrenal injuries is challenging due to the rich vascularity of the adrenal glands and variations in the origin of their blood supply. The adrenal glands receive their blood supply from three primary arteries: the superior, middle, and inferior adrenal arteries, which may originate from various sources, including the inferior phrenic artery, the aorta, and the renal artery. The adrenal parenchyma is characterized by its compact structure and substantial internal vascular connectivity; therefore, embolization of a single artery is unlikely to lead to complete gland infarction. (22) To date, there have been no documented cases of adrenal infarction or insufficiency following TAE for adrenal gland trauma. (14) In circumstances involving uncontrollable hemorrhage or the absence of angiographic interventions, laparotomy with suture hemostasis or adrenalectomy remains a viable option with no significant impact on mortality. (14)

Follow-up

Post-conservative management, vigilant follow-up is customary, with most adrenal hematomas resolving within 2-4 weeks. (6,7,23) Although rebleeding due to the abundant vascular network cannot be entirely precluded, comprehensive arterial evaluations during TAE may not be imperative if the patient exhibits hemodynamic stability. Subsequent CT or angiographic follow-ups are advisable upon signs of persistent hemorrhage. (21)

Mortality and prognosis

While active adrenal hemorrhaging is relatively uncommon (1%-6%), (20) adrenal traumas are often compounded by other injuries, particularly hepatic or rib-related traumas. Although early literature linked adrenal trauma to higher injury severity and mortality, recent studies suggest that adrenal bleeding per se may not significantly elevate mortality, with associated injuries wielding a substantial effect on outcomes. (24)

Conclusion

Traumatic adrenal injuries present a formidable challenge in the realm of trauma management, with incidence rates rising in tandem with advances in imaging technologies. AGI frequently coexists with injuries to proximate organs, impacting ISS. Despite their nonspecific clinical indicators, CT imaging remains indispensable for diagnosis, and while conservative treatment is the frontline approach, interventional procedures are increasingly accessed for active hemorrhaging cases. Emerging evidence indicates that adrenal hemorrhaging itself does not substantially heighten mortality risks, yet associated injuries critically influence outcomes. Continuous follow-up is vital, given that most hematomas resolve within a few weeks. Further investigative efforts are indispensable for the future development of systematic management protocols as trauma care continues to progress.

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Conflict of interest

There are no conflicts of interest associated with this publication.

Table 1. American Association for the Surgery of Trauma (AAST) classification of adrenal injury

Grade	Description in injury
I	Contusion
II	Cortex laceration <2 cm
III	Laceration extending into medulla >2 cm
IV	>50% parenchymal destruction
V	Total parenchymal destruction Massive intraparenchymal hemorrhage Avulsion from blood supply

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