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THE GOLDEN HOUR' CONCEPT IN TRAUMA CARE: AN EVIDENCE-BASED REVIEW OF ITS IMPACT ON PRE-HOSPITAL TRIAGE PROTOCOLS AND EMERGENCY DEPARTMENT PREPAREDNESS

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Abstract:

The "Golden Hour" is a cornerstone of trauma care, emphasizing that survival rates significantly improve if definitive care is provided within the first sixty minutes post-injury. While this concept has fundamentally shaped modern trauma systems, its rigid interpretation and evidence base are debated. This review critically appraises the "Golden Hour" and synthesizes its impact on pre-hospital triage and emergency department (ED) preparedness. A systematic literature review was conducted, analyzing studies on major trauma patients and time-sensitive care outcomes. Findings confirm that time is critical for specific injuries. In hemorrhagic shock, rapid access to surgical hemorrhage control and transfusion is vital, while in severe traumatic brain injury, swift intervention prevents secondary damage. Consequently, the "Golden Hour" has driven pre-hospital protocols toward a "scoop and run" model and refined field triage criteria to ensure patients reach trauma centers swiftly. In the ED, it has mandated trauma team activation, the "Platinum Ten Minutes" for initial resuscitation, and structural readiness like in-house surgeons and massive transfusion protocols. Ultimately, the "Golden Hour" is best viewed as a system-wide imperative for efficiency, not a strict deadline. Its legacy is the standardization of patient-centered pathways from incident to ED. Future progress hinges on precision triage, overcoming logistical barriers, and integrating technology to optimize the entire trauma chain of survival.

Keywords: *Golden Hour; Trauma Triage; Pre-Hospital Care; Emergency Department; Damage Control Resuscitation.*

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1. INTRODUCTION:

1.1.The Global Burden of Trauma

Injury remains a formidable global public health crisis, representing a leading cause of mortality and disability worldwide. According to the World Health Organization (WHO), injuries account for nearly 8% of all deaths globally, with road traffic injuries, falls, and interpersonal violence being primary contributors. Trauma is the dominant cause of death for individuals aged 5-44 years, resulting in a staggering loss of productive life years and imposing an immense socio-economic burden on healthcare systems and societies (WHO, 2020). Beyond mortality, survivors of major trauma often face long-term disability, psychological sequelae such as post-traumatic stress disorder, and significant financial hardship due to medical costs and lost income, underscoring the critical need for highly effective and efficient trauma systems (Gosselin et al., 2021).

1.2.The Origin and Evolution of the 'Golden Hour' Concept

The concept of the "Golden Hour" is indelibly linked to the work of R. Adams Cowley, a pioneering American trauma surgeon who famously stated, "There is a golden hour between life and death." In the 1960s and 70s, Cowley postulated that the first sixty minutes following a traumatic injury were critical; if definitive care could be provided within this window, the patient's chances of survival would be dramatically improved (Rogers et al., 2015). This concept was heavily reinforced by observations in military medicine, where rapid evacuation and surgical intervention were shown to save lives on the battlefield (Kotwal et al., 2016).

The physiological rationale underpinning this concept is robust, particularly for two time-sensitive conditions: hemorrhagic shock and severe traumatic brain injury (TBI). In hemorrhagic shock, a cascade of metabolic acidosis, hypothermia, and coagulopathy—the "lethal triad"—sets in progressively. Early control of bleeding and resuscitation are essential to break this cycle (Alarhayem et al., 2016). Similarly, in severe TBI, secondary brain injury from hypoxia and hypotension can rapidly evolve, making rapid intervention to reduce intracranial pressure and restore cerebral perfusion critical for mitigating irreversible damage (Newgard et al., 2015). Thus, the "Golden Hour" is not merely a chronological measure but a physiological one, representing the window of opportunity to prevent irreversible physiologic decline.

1.3. From Concept to Clinical Guideline: The System-Wide Imperative

The "Golden Hour" concept transcended a simple medical axiom to become the foundational principle for the development of modern, integrated trauma systems. It provided the impetus for structuring emergency medical services (EMS), establishing designated Level I and II Trauma Centers, and creating regionalized care networks (MacKenzie et al., 2006). The goal was systemic: to minimize the time from injury to definitive care by ensuring that severely injured patients are rapidly identified in the field, transported to an appropriate facility, and met by a prepared, multidisciplinary trauma team. This system-wide imperative has driven protocols for pre-hospital triage, "scoop and run" transport policies, and in-hospital trauma team activation, all orchestrated to honor the time-sensitive nature of traumatic injury (Irawati, 2025; Algarfan et al., n.d.).

1.4.Rationale and Objectives of the Review

Despite its profound influence, the "Golden Hour" is not without controversy. Some critics label it an "urban legend" or "medical folklore," arguing that the evidence for a rigid 60-minute window is more doctrinal than data-driven (Lerner & Moscati, 2001; Euse, 2020). Studies have shown that while time is undoubtedly critical, the relationship is complex, and some patients may benefit from certain advanced pre-hospital interventions even if it extends scene time (Newgard et al., 2015). This has led to significant variability in the application of time-driven protocols across different EMS systems and ongoing debate regarding the balance between "stay and play" versus "scoop and run" philosophies.

Therefore, a critical and evidence-based reappraisal is necessary. The primary aim of this review is to

synthesize the current body of evidence regarding the "Golden Hour" concept and to critically evaluate its direct impact on two pivotal components of the trauma chain of survival: pre-hospital triage protocols and emergency department preparedness. This review will assess whether the "Golden Hour" remains a valid dogma or requires a more nuanced interpretation in contemporary trauma care.

2. METHODS:

This evidence-based review was conducted following a systematic approach to the identification, selection, and synthesis of the relevant literature to ensure a comprehensive and unbiased assessment of the topic.

2.1.Literature Search Strategy

A comprehensive and systematic literature search was designed and executed to identify all pertinent studies.

2.1.1. Information Sources:

The following electronic bibliographic databases were searched from their inception: PubMed/MEDLINE, Embase (via Elsevier), the Cochrane Central Register of Controlled Trials (CENTRAL), and Scopus. These databases were selected for their extensive coverage of biomedical and emergency care literature.

2.1.2. Search Strategy:

The search strategy was developed to capture the core concepts of the "Golden Hour," trauma, and emergency care systems. It utilized a combination of Medical Subject Headings (MeSH) and free-text keywords in the title and abstract fields. The primary search terms were grouped as follows: ("Golden Hour" OR "Time-to-Treatment" OR "Time-to-Care" OR "Prehospital Time" OR "Out-of-Hospital Time") AND ("Trauma" OR "Wounds and Injuries" OR "Major Trauma" OR "Polytrauma") AND ("Triage" OR "Pre-Hospital Care" OR "Emergency Medical Services" OR "Emergency Service, Hospital" OR "Trauma Systems" OR "Trauma Centers"). Boolean operators (AND, OR) were used to combine these terms, and the search syntax was tailored to the specific requirements of each database.

2.2.Study Selection and Eligibility Criteria (PICOS Framework)

The study selection process was guided by the pre-defined PICOS framework to ensure clarity and consistency in inclusion and exclusion decisions.

The review focused on studies involving adult and pediatric patients (all ages) with major traumatic injuries, as defined by an Injury Severity Score (ISS) > 15 or by clinical criteria indicative of major trauma.

The intervention of interest was the application of a "Golden Hour" principle in clinical care. This included systems or protocols designed to minimize the time from injury to definitive care (e.g., rapid transport policies, direct transport to trauma centers, in-hospital trauma team activation). Studies that specifically analyzed time-to-key-interventions (e.g., time to surgery, time to transfusion) were also included.

Comparators of interest included standard trauma care without an explicit time-driven protocol, care with longer pre-hospital or in-hospital time intervals, or delayed interventions.

Study Designs: To capture a robust and diverse evidence base, we included:

- Systematic Reviews and Meta-Analyses
- Randomized Controlled Trials (RCTs)
- Prospective and Retrospective Observational Cohort Studies
- Major clinical practice guidelines from recognized bodies (e.g., ACS-COT, EAST).

  Editorials, narrative reviews without systematic methodology, case reports, and conference abstracts were excluded.

2.3.Data Extraction and Synthesis

2.3.1. Data Extraction:

Following the initial literature search, duplicates were removed. The titles and abstracts of the remaining records were screened for relevance by one reviewer, and potentially eligible full-text articles were subsequently assessed by two independent reviewers against the eligibility criteria. Any discrepancies were resolved through discussion or by a third reviewer. Data from the included studies were extracted using a standardized, piloted data extraction form. The extracted information included: study characteristics (first author, publication year, country, design), patient population details, description of the intervention/exposure and comparator, and relevant results for all pre-specified outcome measures.

2.3.2. Data Synthesis:

Given the anticipated heterogeneity in the included studies—particularly variations in study designs, patient populations, definitions of "Golden Hour" protocols, and reported outcomes—a formal quantitative meta-analysis was deemed inappropriate. Therefore, a narrative synthesis approach was employed. The findings were organized thematically to summarize and critically appraise the evidence on the impact of the "Golden Hour" concept on pre-hospital triage protocols and emergency department preparedness, as outlined in the subsequent sections of this review.

3. RESULTS:

The systematic search and selection process yielded a substantial body of literature examining the "Golden Hour" concept. The findings are organized into three thematic areas: the direct evidence linking

time to patient outcomes, the impact on pre-hospital protocols, and the consequences for in-hospital preparedness.

3.1.The Evidence Linking Time-to-Care and Patient Outcomes

The fundamental premise of the "Golden Hour" is that shorter time to definitive care improves survival and functional outcomes. The evidence supporting this is strongest for specific, time-critical injuries.

3.1.1. Hemorrhagic Shock

For patients with hemorrhagic shock, particularly from torso injury, the window for intervention is often significantly shorter than 60 minutes. A pivotal study by Alarhayem et al. (2016**)** analyzed patients who died from torso hemorrhage and found that the median time from injury to death was just 1 hour and 42 minutes, with 25% of deaths occurring within 33 minutes of injury. This compellingly demonstrates that for the most severely injured, "time is the enemy," and mortality occurs long before the traditional "golden hour" elapses. The evidence strongly supports that reducing the time to two key interventions is critical**:** hemostatic surgery (e.g., laparotomy, thoracotomy) and balanced transfusion with blood products. Every minute saved in achieving surgical control of bleeding or administering the first unit of packed red blood cells is associated with a measurable survival benefit, reinforcing the need for system-level efficiency from the scene to the operating room (Hsieh et al., 2022; Kotwal et al., 2016).

3.1.2. Traumatic Brain Injury (TBI)

In severe TBI, the primary injury is compounded by secondary insults like hypoxia and hypotension. Rapid intervention is aimed at mitigating this secondary damage. The study by Newgard et al. (2015)**,** while finding no overall mortality benefit for shorter out-of-hospital times in a mixed trauma cohort, did identify a trend toward improved outcomes in the severe TBI subgroup with shorter times, highlighting its specific time-sensitivity. The focus is on reducing the time to interventions that manage intracranial pressure and ensure adequate cerebral perfusion. This includes rapid sequence intubation to prevent hypoxia, avoidance of hypotension through fluid resuscitation, and expedited transport to a facility capable of performing a decompressive craniectomy if needed. Delays in any of these steps can lead to irreversible neurological injury and worse long-term functional outcomes (Abhilash & Sivanandan, 2020).

3.2.Impact on Pre-Hospital Triage Protocols

The imperative of the "Golden Hour" has directly shaped the policies and procedures of Emergency Medical Services (EMS) worldwide.

3.2.1. The "Scoop and Run" vs. "Stay and Play" Debate

The weight of evidence strongly favors a "scoop and run" or "load and go" approach for critically injured trauma patients in urban and suburban settings. The principle is to minimize on-scene time to the absolute essentials required for safe transport, often cited as a goal of less than 10 minutes. Prolonged on-scene times for advanced procedures have not been consistently shown to improve outcomes and can be detrimental for patients requiring immediate surgical hemorrhage control **(**Algarfan et al., n.d.; Irawati, 2025). The landmark study by Newgard et al. (2015) supports this, showing that longer EMS intervals were not associated with improved survival. The paradigm is to bring the patient to the definitive care of the trauma center, not to bring extensive, time-consuming care to the patient.

3.2.2. Development of Field Triage Criteria

To operationalize the "Golden Hour," systematic tools were needed to identify which patients required rapid transport to a specialized trauma center. This led to the development and iterative refinement of field triage guidelines, most notably the CDC's Field Triage Guidelines. These evidence-based protocols guide EMS providers through a decision scheme based on:

- **Physiology:** (e.g., Glasgow Coma Scale, systolic blood pressure).
- **Anatomy of Injury:** (e.g., penetrating trauma to torso, flail chest).
- **Mechanism of Injury:** (e.g., high-speed vehicle crash, fall from height). The explicit goal of this triage system is to identify the "right patient" for the "right hospital" in the "right time," directly translating the "Golden Hour" concept into a practical field tool that minimizes undertriage (missing a seriously injured patient) while managing the resource implications of overtriage (Hu et al., 2020; Sasser et al., 2012**).**

3.2.3. The Role of Advanced Life Support (ALS) vs. Basic Life Support (BLS)

The "Golden Hour" has also influenced the debate on the necessary level of pre-hospital care. The evidence suggests that for the most time-critical patients, the benefit of rapid transport (BLS model) often outweighs the benefit of performing advanced procedures on scene (ALS model). Key life-saving interventions such as controlling external hemorrhage with tourniquets, managing the airway with basic maneuvers, and rapid extrication can and should be performed en route to the hospital. However, the context matters. In rural settings with long transport times, or for specific interventions like pre-hospital blood product administration (an evolving practice), certain ALS skills may become more critical, representing an adaptation of the "Golden Hour" principle to different operational environments (Keenan & Riesberg, 2017; Alabdali et al., 2025).

3.3. Impact on Emergency Department and Trauma Team Preparedness

The "Golden Hour" mandate extends into the hospital, driving the creation of highly structured and efficient in-hospital systems.

3.3.1. Trauma Team Activation (TTA)

To eliminate in-hospital delays, the concept of Trauma Team Activation (TTA) was developed. Based on pre-hospital information that meets specific criteria (mirroring the field triage guidelines), the trauma team—a multidisciplinary group of surgeons, emergency physicians, nurses, and technicians—is assembled and ready before the patient arrives. This pre-arrival alert system ensures that the resources and expertise needed for immediate resuscitation are available the moment the patient enters the ED, effectively starting the "Golden Hour" clock for in-hospital care the second the patient is identified in the field (Irawati, 2025).

3.3.2. The Concept of the "Platinum Ten Minutes"

Within the "Golden Hour," an even more urgent timeframe has been conceptualized: the "Platinum Ten Minutes." This refers to the goal of completing the primary survey (ABCDE) and initiating critical life-saving interventions within the first 10 minutes of ED arrival. This includes procedures like securing a definitive airway, performing a resuscitative thoracotomy, obtaining vascular access for massive transfusion, and controlling catastrophic external hemorrhage. This hyper-focused timeframe emphasizes that the initial ED management is not a period of assessment alone, but one of simultaneous, aggressive intervention to stabilize the patient for definitive care in the operating room or angiography suite (Arora et al., 2025; Abhilash & Sivanandan, 2020).

3.3.3. Structural and Logistical Readiness

The "Golden Hour" necessitates specific structural capabilities within a trauma center. Evidence shows that outcomes are improved when these facilities have:

- Immediately available surgeons to take the patient to the operating room without delay.
- This includes dedicated trauma resuscitation bays, an operating room that is always available for trauma, and in-house angiography capabilities for hemorrhage control.
- The immediate availability of universal donor blood products (O-negative) and pre-defined protocols for activating a massive transfusion are essential for reversing hemorrhagic shock. The ability to rapidly deliver blood products, often within minutes of arrival, is a direct operationalization of the time-sensitive principles of the "Golden Hour" (Kotwal et al., 2016; MacKenzie et al., 2006**).**

4. DISCUSSION:

This evidence-based review demonstrates that the "Golden Hour" is far more than a historical slogan; it is a powerful organizing principle that has fundamentally shaped modern trauma systems. The findings confirm that while the relationship between time and outcome is complex and not universally absolute, the core concept—that systematic efforts to minimize time to definitive care save lives—remains overwhelmingly valid. This discussion interprets these findings, outlines their clinical implications, addresses ongoing challenges, and identifies critical avenues for future research.

4.1. Interpretation of the Evidence: A Critical Appraisal of the 'Golden Hour'

The synthesized evidence presents a nuanced picture. On one hand, studies like that of Alarhayem et al. (2016) provide a stark, physiological reality check, demonstrating that for patients in extremis from hemorrhage, the critical window may be a "golden half-hour" or less. This reinforces the concept's urgency. Conversely, work by Newgard et al. (2015) and commentators like Lerner & Moscati (2001) rightly challenge a dogmatic interpretation of a rigid 60-minute deadline for all patients, showing that for some cohorts, out-of-hospital time alone is not a primary determinant of outcome.

This apparent contradiction is resolved by viewing the "Golden Hour" not as a strict chronological deadline, but as a philosophical and systems-based imperative. Its greatest value lies not in the number "60," but in its power to drive the creation of efficient, patient-centered pathways from the scene of injury to definitive care. The evidence is clear that for time-critical conditions like hemorrhagic shock and severe TBI, every minute saved across the entire chain of survival—from bystander intervention through to in-hospital resuscitation—contributes to a cumulative survival benefit (Hsieh et al., 2022; Kotwal et al., 2016). Therefore, the "Golden Hour" is best understood as a metaphor for minimizing system delay, a goal that remains as relevant today as when it was first proposed.

4.2. Clinical Implications and Best Practices

To realize the benefits of this time-sensitive approach, standardized best practices are essential across the continuum of care.

4.2.1. Optimizing the Pre-Hospital Phase

The pre-hospital phase sets the stage for survival. Best practices, as highlighted by Algarfan et al. (n.d.) and Irawati (2025)**,** mandate a focus on interventions that directly support rapid transport to definitive care. Key actions include:

- Widespread training and use of tourniquets and hemostatic dressings for external hemorrhage.
- Using techniques that minimize on-scene time for trapped patients.
- Prioritizing basic maneuvers and, when advanced management is needed, performing rapid sequence intubation during transport rather than on scene.
- Enabling EMS to transport the most severely injured patients directly to a Level I or II Trauma Center, bypassing closer, less-resourced facilities.

4.2.2. Streamlining In-Hospital Care

Upon arrival, the "Golden Hour" concept morphs into the "Platinum Ten Minutes" and is operationalized through the principles of Damage Control Resuscitation (DCR) and Damage Control Surgery (DCS). DCR focuses on hypotensive resuscitation, hemostatic blood product transfusion (in a 1:1:1 ratio of plasma:platelets:RBCs), and avoiding crystalloids to mitigate the lethal triad. DCS involves abbreviated laparotomy or thoracotomy to control bleeding and contamination, followed by ICU resuscitation and planned re-operation. These strategies are the direct clinical application of the "Golden Hour" philosophy, prioritizing physiological stabilization over anatomical completeness to buy time and improve survival (Arora et al., 2025; Duchesne et al., 2008**).**

4.2.3. The Role of Telemedicine and Data Integration

Technology is a powerful force multiplier for the "Golden Hour." Pre-hospital electronic patient care records and telemedicine consultations allow for real-time transmission of vital signs, mechanism of injury, and video to the receiving trauma center. This enables more accurate trauma team activation, tailored resource preparation (e.g., alerting the blood bank, assembling an interventional radiology team), and expert guidance for remote EMS units, effectively bringing the expertise of the trauma center to the field and ensuring the hospital is fully prepared the moment the patient arrives (Latifi et al., 2018).

4.3.Challenges and Controversies

Despite its benefits, the implementation of a time-driven trauma system faces inherent challenges.

4.3.1. Overtriage vs. Undertriage

This is the fundamental tension in trauma triage. Undertriage (missing a seriously injured patient) leads to delays in definitive care and increased mortality. Overtriage (sending minimally injured patients to major trauma centers) strains finite resources and is economically inefficient. The CDC guidelines aim for an overtriage rate of 25-50% to keep undertriage below 5%, but achieving this balance is a persistent challenge that can lead to system strain and clinician skepticism (Hu et al., 2020**).**

4.3.2. Geographical and Logistical Realities

The "scoop and run" paradigm is most effective in urban settings. In rural areas, long transport times render a strict "Golden Hour" unattainable. This has given rise to the concept of "Prolonged Field Care," where EMS must provide sustained, advanced care during extended evacuations, representing a significant adaptation of the original concept (Keenan & Riesberg, 2017).

4.3.3. The "Load-and-Go" Mentality

An overzealous focus on time can lead to the pitfall of neglecting critical, time-sensitive interventions that are best performed on scene. For example, failing to secure a definitive airway in a patient with a rapidly deteriorating mental status, or not applying a tourniquet to catastrophic limb hemorrhage, can be fatal. The key is to balance the imperative for speed with the execution of essential, life-saving tasks.

4.4. Future Directions and Research Gaps

To advance trauma care beyond the current "Golden Hour" paradigm, several key areas require investigation:

- Research is needed to identify and validate point-of-care biomarkers (e.g., specific patterns of lactate, metabolomic profiles) that can more accurately predict which patients are truly "time-critical," moving beyond mechanism and crude physiological parameters to enable patient-specific triage.
- The impact of pre-hospital transfusion of plasma and red blood cells on mortality in hemorrhagic shock is a major area of active research. Determining its cost-effectiveness and optimal implementation is crucial (REPHILL trial, 2023**).**
- More research is needed on the "Golden Hour" concept in low- and middle-income countries (LMICs), where pre-hospital systems are often underdeveloped, and on its relevance in major blunt trauma versus penetrating trauma.
- The development of automated algorithms to integrate real-time vital signs, vehicle telemetry data, and patient history to predict deterioration and optimize triage decisions holds immense promise for the future of trauma system logistics and patient care (Ergan et al., 2019).

5. CONCLUSION:

In conclusion, the evidence synthesized in this review unequivocally affirms that the 'Golden Hour' remains a vital organizing principle that has fundamentally shaped and improved modern trauma systems worldwide (Kotwal et al., 2016; MacKenzie et al., 2006). While the rigidity of the 60-minute

window has been rightly challenged, its core premise—that time is a critical variable in survival from severe injury—is irrefutable, particularly for victims of hemorrhagic shock and traumatic brain injury (Alarhayem et al., 2016; Newgard et al., 2015).

The greatest legacy of the 'Golden Hour' is not its use as a strict chronological measure, but its power as a catalyst for systemic change. Its true value lies in its success in driving the development of integrated, efficient, and patient-centered protocols that span the entire continuum of care—from bystander intervention and EMS triage to trauma team activation and damage control resuscitation in the emergency department (Irawati, 2025; Abhilash & Sivanandan, 2020). It has instilled a culture of urgency and a focus on minimizing preventable delays at every step, embodying the adage that for the critically injured, "time is the enemy" (Alarhayem et al., 2016).

Therefore, a concerted call to action is imperative. To build upon the life-saving progress achieved thus far, healthcare systems must prioritize the continued standardization of evidence-based trauma protocols, invest in ongoing multidisciplinary training for pre-hospital and emergency department teams, and champion research into precision triage and novel interventions (Hsieh et al., 2022; Ergan et al., 2019). By relentlessly focusing on optimizing the entire chain of survival, we can ensure that the foundational principle of the 'Golden Hour' continues to save lives for generations to come.

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