Test file： The Impact of Structured Anti-Infective Nursing Care on Outcomes in Emergency Surgical Trauma Patients: A Quasi-Experimental Study

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Abstract

Background: Sepsis and surgical site infections (SSIs) are major causes of morbidity and mortality following traumatic injury. While prompt surgical intervention and antibiotics are critical, the role of protocolized, nurse-driven anti-infective care in the emergency setting remains underexplored. This study evaluated the effectiveness of a structured, multi-component anti-infective nursing bundle on clinical outcomes in emergency surgical trauma patients. Methods: A quasi-experimental, pre-post intervention study was conducted at a Level I trauma center. The control group consisted of 415 patients admitted between July and December 2022, receiving standard care. The intervention group consisted of 428 patients admitted between January and June 2023, managed with a novel "TIME" nursing bundle: Timely administration of antibiotics and cultures, Intensive metabolic control (glycemic & temperature), Meticulous wound and catheter care, and Early source control coordination. Primary outcomes were the incidence of sepsis within 72 hours and SSI within 30 days. Secondary outcomes included antibiotic days, length of ICU stay, and 30-day mortality. Data were analyzed using chi-square tests, t-tests, and multivariate logistic regression. Results: Implementation of the TIME bundle was associated with significant improvements. The sepsis rate decreased from 18.1% to 11.0% ($p<0.01$), and the SSI rate decreased from 12.3% to 7.0% ($p<0.01$). Patients in the intervention group had fewer mean antibiotic days (5.2 vs. 7.8, $p<0.01$), shorter ICU stays (4.5 vs. 6.1 days, $p<0.05$), and lower 30-day mortality (8.6% vs. 12.8%, $p<0.05$). After adjusting for injury severity, the TIME bundle was an independent protective factor against sepsis (aOR 0.52, 95% CI 0.34-0.79) and SSI (aOR 0.49, 95% CI 0.30-0.80). Conclusion: A structured, nurse-led anti-infective care bundle significantly reduced the incidence of early sepsis and surgical site infections in emergency trauma surgery patients, and was associated with improved antibiotic stewardship and clinical outcomes. These findings highlight the pivotal role of targeted nursing interventions in the multidisciplinary effort to prevent infections in trauma care.

Keywords: Trauma Nursing; Infection Control; Sepsis; Surgical Site Infection; Emergency Surgery; Nursing Bundle; Antibiotic Stewardship.

1. Introduction

Trauma is a leading cause of death and disability globally, with infection being a formidable secondary threat that can undermine even successful initial surgical resuscitation [1]. Emergency surgical trauma patients are uniquely vulnerable to infections such as sepsis and surgical site infections (SSIs) due to factors including open wounds, invasive procedures, tissue hypoperfusion, and the systemic immunosuppressive effects of major injury [2]. The consequences are severe, with infections leading to prolonged hospitalization, increased healthcare costs, multi-organ failure, and elevated mortality [3].

The clinical approach to infection in trauma has traditionally been surgeon- and pharmaco-centric, focusing on rapid source control and timely, broad-spectrum antibiotic administration [4]. However, the continuum of care from the emergency department through the operating room to the ICU involves numerous nursing-sensitive practices that directly influence infection risk. These include the timing of blood cultures and first antibiotic dose, maintenance of normothermia, glycemic control, wound management, and care of invasive lines and catheters [5]. While individual components are supported by guidelines, their integration into a cohesive, protocolized nursing care bundle specifically for the emergency trauma patient population has not been extensively studied.

Evidence from critical care settings shows that care bundles—structured sets of evidence-based interventions—can significantly improve outcomes for conditions like ventilator-associated pneumonia and central line-associated bloodstream infections [6]. Translating this bundle methodology to the dynamic, high-acuity context of emergency trauma surgery could optimize the anti-infective process of care. This study aimed to develop, implement, and evaluate the effectiveness of a multi-component "TIME" anti-infective nursing care bundle on the incidence of sepsis and SSIs in patients undergoing emergency trauma surgery.

2. Methods

2.1 Study Design and Setting

A quasi-experimental pre-post intervention study was conducted at a high-volume, urban Level I trauma center. The study was approved by the Institutional Review Board with a waiver of informed consent for the retrospective analysis of the pre-intervention phase. Verbal consent was obtained from nursing staff for educational components of the intervention phase.

2.2 Participants

Consecutive adult patients (≥18 years) admitted through the emergency department who required urgent surgical intervention (laparotomy, thoracotomy, vascular repair, or major orthopedic fixation) within 12 hours of admission were included. Exclusion criteria were: isolated traumatic brain injury, burns covering >20% total body surface area, do-not-resuscitate status on admission, or death within 24 hours of admission.

2.3 Intervention: The "TIME" Nursing Care Bundle

The intervention was a structured, nurse-driven protocol implemented over a one-month training period and applied throughout the patient's initial hospitalization. The bundle comprised four pillars:

T - Timely Administration & Cultures:
Nurse-Initiated Blood Cultures: Drawing two sets of blood cultures before the first antibiotic dose for any trauma patient with a suspected infection or SIRS criteria [7].
Antibiotic Time-Keeper: A designated nurse role to ensure the first dose of prescribed antibiotics is administered within 60 minutes of the order, with electronic time-stamp documentation [8].

I - Intensive Metabolic Control:
Active Warming Protocol: Mandatory use of forced-air warming blankets and warmed IV fluids from admission to achieve and maintain a core temperature ≥36.5°C, documented hourly for the first 6 hours [9].
Tight Glycemic Monitoring: Point-of-care blood glucose testing on admission and every 4 hours for the first 24 hours, with a nurse-driven insulin sliding scale protocol targeting a range of 140-180 mg/dL [10].

M - Meticulous Wound & Catheter Care:
Pre-Op Skin Prep Audit: Nurses verified and documented the completion of a chlorhexidine gluconate (CHG) skin preparation in the operating room according to protocol [11].
Central Line Bundle Compliance: Strict adherence to a checklist for maximal sterile barrier during insertion and daily audits of line necessity [12].
Early Wound Assessment: Standardized postoperative wound assessment using the ASEPSIS score within the first 24 hours and daily thereafter [13].

E - Early Source Control Coordination:
Nurse as Communicator: The primary trauma nurse was tasked with proactively communicating early signs of potential infection (e.g., worsening physiology, concerning wound appearance) to the surgical team to expedite decisions regarding imaging or re-operation [14].

2.4 Control Group and Data Collection

The control group received standard trauma care, which included general infection prevention principles but lacked the formalized, audited structure of the TIME bundle. Data for both groups were collected retrospectively from the electronic health record, trauma registry, and infection control database. Variables included demographics, Injury Severity Score (ISS), surgery type, compliance with bundle elements, and outcome measures.

2.5 Outcome Measures

Primary Outcomes: 1) Incidence of sepsis/septic shock within 72 hours of admission (defined by Sepsis-3 criteria [15]). 2) Incidence of SSI within 30 days postoperatively (defined by CDC/NHSN criteria [16]).
Secondary Outcomes: Total antibiotic days of therapy (DOT), ventilator days, length of ICU and hospital stay, and 30-day all-cause mortality.

2.6 Statistical Analysis

Data were analyzed using SPSS v.28. Categorical variables were compared using the Chi-square test. Continuous variables were compared using Student's t-test or the Mann-Whitney U test.

Multivariate logistic regression was performed to assess the independent effect of the TIME bundle on primary outcomes, adjusting for age, ISS, and presence of open fracture. Statistical significance was set at $p < 0.05$.

3. Results

3.1 Baseline Characteristics

A total of 843 patients were analyzed (Control: n=415; Intervention: n=428). The groups were well-matched in terms of age, gender, and mechanism of injury (predominantly blunt trauma). The mean ISS was comparable (Control: 24.5 ± 8.1; Intervention: 23.8 ± 7.9, p=0.21). The distribution of surgical procedures (abdominal, thoracic, orthopedic) was similar between groups.

3.2 Bundle Compliance and Process Measures

In the intervention group, overall compliance with the complete TIME bundle was 78%. Significant improvements were seen in key process measures compared to the control group: antibiotic administration within 60 minutes increased from 65% to 92% (p<0.01), documented normothermia in the first 6 hours increased from 58% to 85% (p<0.01), and pre-operative CHG skin prep verification reached 95%.

3.3 Primary Clinical Outcomes

The implementation of the TIME bundle led to significant reductions in infection rates.
Sepsis within 72 hours: The incidence fell from 18.1% (75/415) in the control group to 11.0% (47/428) in the intervention group (p<0.01).
Surgical Site Infection: The SSI rate decreased from 12.3% (51/415) to 7.0% (30/428) (p<0.01). Reductions were seen across superficial, deep, and organ-space infection categories.

3.4 Secondary Outcomes and Multivariate Analysis

Patients receiving the TIME bundle had significantly better secondary outcomes:
Mean antibiotic DOT: 5.2 vs. 7.8 days (p<0.01)
Mean ICU length of stay: 4.5 vs. 6.1 days (p<0.05)
0-day mortality: 8.6% vs. 12.8% (p<0.05)
Multivariate analysis confirmed the TIME bundle as an independent protective factor against both sepsis (Adjusted Odds Ratio [aOR] 0.52, 95% CI 0.34-0.79) and SSI (aOR 0.49, 95% CI 0.30-0.80), after controlling for injury severity and age.

4. Discussion

This study demonstrates that a structured, nurse-driven anti-infective care bundle can significantly improve clinical outcomes for emergency surgical trauma patients. The 39% relative reduction in early sepsis and 43% relative reduction in SSI underscore the profound impact that systematizing fundamental nursing care can have on the biology of infection in this vulnerable population.

The success of the TIME bundle can be attributed to its multi-pronged attack on the pathogenesis of post-traumatic infection. First, the "Timely" component directly addresses the golden hour for sepsis management. The dramatic improvement in antibiotic administration time mirrors findings from the Surviving Sepsis Campaign, where each hour of delay is associated with a measurable increase in mortality [17]. Empowering nurses to draw cultures before antibiotics is a crucial step in promoting targeted, rather than indefinite, empiric therapy.

Second, the "Intensive Metabolic Control" pillar tackles key modifiable risk factors. Hypothermia, common in trauma due to exposure and resuscitation, impairs neutrophil function and coagulation [9]. Our active warming protocol achieved high rates of normothermia, likely contributing to reduced infection and transfusion needs. Similarly, early stress-induced hyperglycemia is a known immune suppressant; our nurse-driven glucose protocol provided a pragmatic approach to mitigating this risk [10].

Third, "Meticulous Care" of wounds and catheters addresses the primary portals of entry for pathogens. The near-universal verification of proper skin antisepsis is a simple but critical intervention supported by strong evidence for reducing SSIs [11]. The focus on central line care aims to prevent iatrogenic bloodstream infections, a known complication in critically injured patients [12].

Finally, the "Early Coordination" role formalizes the nurse's unique perspective as the constant bedside caregiver, enabling earlier detection of subtle clinical changes and promoting proactive communication with the surgical team—a concept central to preventing failure-to-rescue events [14].

Our findings on reduced antibiotic use and shorter ICU stays have important health-economic implications, suggesting that investing in nursing protocols can improve resource utilization. The reduction in mortality, while secondary, is clinically meaningful and aligns with the known mortality burden of healthcare-associated infections in trauma [3].

Limitations and Future Directions: This study has limitations. Its single-center, pre-post design may be subject to temporal biases and unmeasured confounders, though the multivariate analysis attempted to adjust for key factors. The Hawthorne effect may have influenced nursing behavior during the study period. Future research should involve a multi-center, randomized controlled design to confirm efficacy. Additionally, investigating the cost-effectiveness of bundle implementation and its impact on long-term functional outcomes and antimicrobial resistance patterns would be valuable.

5. Conclusion

In conclusion, the implementation of the TIME (Timely, Intensive metabolic control, Meticulous care, Early coordination) anti-infective nursing care bundle was associated with a significant reduction in sepsis and surgical site infections among emergency surgical trauma patients. By standardizing and empowering nursing practices across the domains of medication administration, physiological stabilization, wound care, and interdisciplinary communication, this approach provides a practical and effective model for enhancing the quality of trauma care. It reaffirms that infection prevention in trauma is not solely dependent on operative skill or antibiotic choice, but is fundamentally a team effort where nursing care is a powerful and measurable determinant of patient outcome.

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