e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(2); 1173-1176

Original Research Article

Early Low-Dose Noradrenaline Infusion as an Adjunct to Standard ATLS Protocol in the Resuscitation of Hypovolemic Shock among Polytrauma Patients with long bone fractures: A Prospective Comparative Study

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Received: 01-12-2025 / Revised: 15-01-2026 / Accepted: 22-02-2026
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Conflict of interest: Nil

Abstract

Background: Hypovolemic shock remains a leading cause of early preventable mortality in polytrauma patients worldwide. Conventional Advanced Trauma Life Support (ATLS) guidelines emphasize aggressive fluid resuscitation; however, excessive crystalloid administration is associated with dilutional coagulopathy, tissue edema, and adverse outcomes. Early vasopressor support with low-dose noradrenaline may facilitate rapid hemodynamic stabilization while reducing fluid overload.

Objectives: To compare the effectiveness of conventional ATLS protocol alone versus ATLS protocol combined with early low-dose noradrenaline infusion in adult polytrauma patients presenting with hypovolemic shock.

Methods: This prospective comparative study included 60 adult polytrauma patients with hypovolemic shock, randomized into two groups: ATLS-only (n=30) and ATLS plus early noradrenaline (n=30). Primary outcomes included time to achieve systolic blood pressure (SBP) ≥90 mm Hg, fluid requirement in the first 3 hours, and time to heart rate normalization. Secondary outcomes included urine output at 3 hours, lactate clearance at 6 hours, Glasgow Coma Scale (GCS) improvement, ICU admission, and in-hospital mortality.

Results: Baseline characteristics were comparable between groups. The noradrenaline group achieved target SBP significantly faster, required lower fluid volumes, and showed earlier heart rate normalization ($p<0.001$). Urine output, lactate clearance, and GCS improvement were significantly better in the intervention group ($p<0.05$). ICU admission and mortality were lower but not statistically significant.

Conclusion: Early low-dose noradrenaline infusion as an adjunct to ATLS significantly improves early hemodynamic and physiological outcomes in hypovolemic polytrauma patients.

Keywords: Hypovolemic shock; Polytrauma; Noradrenaline; Fluid resuscitation; Vasopressors; ATLS.
DOI: 10.25258/ijcpr.18.2.194

Introduction

Trauma is a major contributor to global morbidity and mortality, particularly among individuals younger than 45 years, with haemorrhage-induced hypovolemic shock accounting for a substantial proportion of early trauma-related deaths [1,2].

Rapid identification and effective management of hypovolemic shock remain critical determinants of survival in polytrauma patients. Despite advances in trauma systems, haemorrhage continues to be the most preventable cause of early trauma mortality [3]. The Advanced Trauma Life Support (ATLS) protocol provides a structured framework for the initial management of trauma patients, prioritizing airway, breathing, and circulation with early volume resuscitation [4]. Traditionally, aggressive crystalloid infusion has been advocated to restore circulating volume and tissue perfusion.

However, increasing evidence indicates that excessive fluid administration may be harmful, leading to dilutional coagulopathy, hypothermia, acidosis, and increased bleeding, thereby worsening outcomes [5]. Polytrauma patients often present with complex physiological disturbances, including hypotension, tachycardia, metabolic

acidosis, and altered mental status. In such patients, reliance on fluid resuscitation alone may fail to rapidly restore adequate perfusion pressure, particularly in the presence of ongoing haemorrhage [6]. This has led to the evolution of restrictive fluid strategies and the concept of balanced resuscitation. Vasopressors, especially noradrenaline, are widely used in septic shock to restore vascular tone and maintain mean arterial pressure. Their role in trauma-induced hypovolemic shock has traditionally been limited due to concerns regarding vasoconstriction-induced tissue ischemia and impaired microcirculation [7]. Observational studies have reported associations between early vasopressor use and increased mortality in trauma patients; however, these studies were often confounded by injury severity and non-standardized dosing practices [8].

Emerging evidence suggests that early administration of low-dose vasopressors, in conjunction with controlled fluid resuscitation, may improve hemodynamic stability without compromising tissue perfusion [4,9]. Noradrenaline increases systemic vascular resistance and venous return, thereby improving blood pressure and cardiac output while potentially reducing fluid requirements. Early stabilization of blood pressure is particularly important in trauma patients with associated traumatic brain injury, where hypotension is a strong predictor of poor neurological outcomes [10].

Markers of effective resuscitation, such as urine output and lactate clearance, have gained prominence as indicators of adequate tissue perfusion and metabolic recovery [11]. Improved lactate clearance within the early hours of resuscitation has been consistently associated with improved survival in critically ill patients. Therefore, strategies that enhance early metabolic recovery may translate into better clinical outcomes. Despite growing interest, prospective studies evaluating the early use of low-dose noradrenaline during the initial emergency department resuscitation of hypovolemic polytrauma patients remain limited, particularly in resource-constrained settings. This study was undertaken with the

Objective: To compare conventional ATLS-based resuscitation with an approach incorporating early low-dose noradrenaline infusion and to assess its impact on early hemodynamic and clinical outcomes.

Materials and Methods

This prospective comparative study was conducted in the Emergency Department of Government Mohan Kumaramangalam Medical College Hospital, Salem, from February 2023 to August 2024. Sixty adult polytrauma patients presenting with hypovolemic shock were enrolled.

Inclusion criteria were age 18–45 years, presentation within 6 hours of injury, systolic blood pressure <90 mm Hg, and heart rate >110 beats per minute. Patients with prior vasopressor use, cardiac arrest before enrolment, pregnancy, major cardiac or spinal injuries, or significant comorbid illnesses were excluded. Patients were randomly allocated into two groups: Group A received standard ATLS-based resuscitation, while Group B received standard ATLS resuscitation along with early low-dose noradrenaline infusion titrated to maintain SBP ≥90 mm Hg. Clinical parameters were recorded at 15-minute intervals. Laboratory investigations included complete blood count, renal and liver function tests, and serum lactate levels.

The study protocol was approved by the Institutional Ethics Committee of GMKMCH, Salem, and informed consent was obtained from patients or their legally authorized representatives prior to enrolment.

Results

Table 1. Baseline Characteristics of study participants (n = 60) in a study on early low-dose noradrenaline infusion as an adjunct to standard ATLS protocol in the resuscitation of hypovolemic shock among polytrauma patients

Parameter	ATLS Only Group (n = 30)	ATLS + Early Noradrenaline Group (n = 30)	p value
Mean age (years)	31.4 ± 6.8	32.2 ± 7.1	0.62
Gender (Male: Female)	22: 8	23: 7	0.77
Time since injury (hours)	3.4 ± 1.2	3.1 ± 1.4	0.48
Mean systolic BP on arrival (mm Hg)	82.6 ± 5.1	81.9 ± 6.0	0.61
Mean heart rate on arrival (beats/min)	122.5 ± 11.3	124.3 ± 10.9	0.52

Table 1 shows the baseline demographic and clinical characteristics of the 60 polytrauma patients included in the study. The mean age of patients in the ATLS-only group was 31.4 ± 6.8 years, while in the ATLS plus early noradrenaline group it was 32.2 ± 7.1 years, with no statistically significant difference (p = 0.62). Male predominance was observed in both groups, with a male-to-female ratio of 22:8 in the ATLS-only group and 23:7 in the intervention group (p = 0.77).

The mean time since injury at presentation was comparable between the two groups, being 3.4 ± 1.2 hours in the ATLS-only group and 3.1 ± 1.4 hours in the ATLS plus noradrenaline group (p = 0.48). On arrival, mean systolic blood pressure was 82.6 ± 5.1 mm Hg in the ATLS-only group and 81.9 ± 6.0 mm Hg in the intervention group (p = 0.61). Similarly, mean heart rate on arrival was 122.5 ± 11.3 beats per minute in the ATLS-only group and 124.3 ± 10.9 beats per minute in the noradrenaline group (p = 0.52). These findings indicate that both groups were comparable at baseline with respect to demographic variables, injury timing, and initial hemodynamic status.

Table 2. Primary hemodynamic outcomes of study participants (n = 60) in a study on early low-dose noradrenaline infusion as an adjunct to standard ATLS protocol in the resuscitation of hypovolemic shock among polytrauma patients

Parameter	ATLS Only Group (n = 30)	ATLS + Early Noradrenaline Group (n = 30)	p value
Time to achieve SBP ≥ 90 mm Hg (minutes)	38.2 ± 10.6	21.5 ± 7.4	<0.001
Fluid volume administered in first 3 hours (ml)	2800 ± 650	1900 ± 520	<0.001
Time to heart rate normalization (minutes)	60.4 ± 15.2	38.8 ± 12.3	<0.001

Table 2 compares the primary hemodynamic outcomes between the two study groups. Patients in the ATLS plus early noradrenaline group achieved the target systolic blood pressure of ≥90 mm Hg significantly faster, with a mean time of 21.5 ± 7.4 minutes, compared to 38.2 ± 10.6 minutes in the ATLS-only group (p < 0.001). The total volume of fluids administered during the first 3 hours of resuscitation was significantly lower in the intervention group, at 1900 ± 520 ml, compared to 2800 ± 650 ml in the ATLS-only group (p < 0.001). Additionally, the mean time to heart rate normalization was shorter in patients receiving early noradrenaline, at 38.8 ± 12.3 minutes, compared to 60.4 ± 15.2 minutes in the ATLS-only group (p < 0.001). These results demonstrate significant differences in early hemodynamic stabilization between the two groups.

Table 3. Secondary Clinical Outcomes of study participants (n = 60) in a study on early low-dose noradrenaline infusion as an adjunct to standard ATLS protocol in the resuscitation of hypovolemic shock among polytrauma patients

Parameter	ATLS Only Group (n = 30)	ATLS + Early Noradrenaline Group (n = 30)	p value
Urine output at 3 hours (ml)	65 ± 22	88 ± 24	0.002
Lactate clearance at 6 hours (%)	32.1 ± 10.4	49.3 ± 11.7	<0.001
GCS improvement at 6 hours (mean ± SD)	2.1 ± 1.0	3.2 ± 1.3	0.01
ICU admission required (%)	70%	50%	0.10
In-hospital mortality (%)	20%	6.7%	0.08

Table 3 presents the secondary clinical outcomes of the study. Urine output measured at 3 hours was higher in the ATLS plus noradrenaline group, with a mean value of 88 ± 24 ml, compared to 65 ± 22 ml in the ATLS-only group, and this difference was statistically significant (p = 0.002). Lactate clearance at 6 hours was also significantly greater in the intervention group, with a mean clearance of 49.3 ± 11.7%, compared to 32.1 ± 10.4% in the ATLS-only group (p < 0.001). Improvement in Glasgow Coma Scale score at 6 hours was higher in patients receiving early noradrenaline, with a mean improvement of 3.2 ± 1.3, compared to 2.1 ± 1.0 in the ATLS-only group (p = 0.01).

ICU admission was required in 50% of patients in the noradrenaline group, compared to 70% in the ATLS-only group (p = 0.10). In-hospital mortality was lower in the intervention group at 6.7%, compared to 20% in the ATLS-only group; however, this difference did not reach statistical significance (p = 0.08).

Discussion:

This study demonstrates that early low-dose noradrenaline infusion, when used as an adjunct to standard ATLS resuscitation, results in faster hemodynamic stabilization and reduced fluid requirements in hypovolemic polytrauma patients. Rapid achievement of target blood pressure is essential in trauma care, as prolonged hypotension is associated with increased mortality and secondary organ injury [1,10].

The fluid-sparing effect observed in this study is clinically relevant. Excessive crystalloid resuscitation has been associated with worse outcomes due to dilutional coagulopathy and tissue edema [5]. Early vasopressor support may reduce these complications by restoring vascular tone and venous return without excessive volume loading [4].

Improved urine output and lactate clearance in the intervention group indicate better end-organ

perfusion and metabolic recovery. Lactate clearance is a validated marker of effective resuscitation and has been linked to improved survival [11]. The findings suggest that early noradrenaline use does not impair microcirculation when administered at low doses under controlled conditions.

The greater improvement in GCS scores observed in the noradrenaline group highlights the importance of early blood pressure stabilization in preserving cerebral perfusion, especially in polytrauma patients with potential head injury [10]. Although ICU admission and mortality were lower in the intervention group, the lack of statistical significance may be attributed to the limited sample size.

Previous studies reporting increased mortality with vasopressor use in trauma patients often involved higher doses, delayed hemorrhage control, and more severely injured cohorts [8]. In contrast, the present study emphasizes early, low-dose, titrated use as an adjunct rather than a substitute for fluid resuscitation.

Overall, these findings support a balanced resuscitation approach that integrates early vasopressor support with controlled fluid administration, particularly in carefully selected hypovolemic trauma patients.

Conclusion

Early low-dose noradrenaline infusion in addition to standard ATLS protocol significantly improves early hemodynamic stability, reduces fluid requirements, and enhances physiological recovery in hypovolemic polytrauma patients.

Strengths and Limitations: The strengths of this study include its prospective design, standardized protocol, and comprehensive evaluation of hemodynamic and metabolic outcomes.

Limitations include the single-center design, relatively small sample size, and lack of long-term outcome assessment.

Recommendations: Early low-dose noradrenaline may be considered as an adjunct to fluid resuscitation in selected hypovolemic polytrauma patients under close monitoring. Larger multicentric randomized controlled trials are recommended to validate these findings and establish definitive clinical guidelines.

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