

Urban vs Rural: Is There a Difference in Outcomes for Patients Who Undergo Pre-Hospital Needle Decompression?"



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Abstract

Background: Tension pneumothorax, a life-threatening thoracic trauma complication, requires urgent pre-hospital needle decompression (ND). This study compares ND outcomes in urban (New Orleans) versus rural (Fargo, ND) settings, where transport times and resources differ.

Methods: Retrospective analysis of 702 adult trauma patients (643 urban, 59 rural) receiving pre-hospital ND at urban Level 1 and rural Level 2 trauma centers (2012–2023). Primary outcome: mortality, including return of spontaneous circulation (ROSC) post-arrest. Secondary outcomes: pre-hospital cardiac arrest, hospital length of stay (LOS). Data analyzed with univariate and multivariate methods, adjusting for age, injury severity, mechanism, transport/on-scene time; p≤0.05 significant.

Results: Urban patients were younger (35.5 vs 48.6 years, p<0.001) with more penetrating injuries (68% vs 25%, p<0.001). Rural patients had longer on-scene (13 vs 9 min, p<0.001) and transport times (45 vs 11 min, p<0.001). Urban patients more often received bilateral ND (58% vs 20%, p=0.003). Pre-hospital cardiac arrest (62% vs 28%, p=0.002) and mortality (60% vs 40%, p=0.03) were higher in urban settings. ROSC rates: 38% urban vs 25% rural. Rural setting was protective against mortality (OR 0.23, p=0.016) and arrest (OR 0.41, p=0.008). LOS was longer in rural survivors (p=0.03). ND appropriateness: 75% urban vs 85% rural (p=0.09).

Conclusions: Rural patients undergoing ND had lower mortality and cardiac arrest despite longer transport times, likely due to effective EMS protocols. Findings highlight opportunities to improve urban ND practices. Prospective studies are needed to optimize techniques.

Introduction

Thoracic trauma frequently results in tension pneumothorax, a life-threatening condition characterized by increased intrathoracic pressure that compromises respiratory and cardiovascular function.⁵ Prompt decompression is essential to prevent adverse outcomes, with pre-hospital needle decompression (ND) serving as a critical intervention within advanced trauma life support frameworks.⁶ Despite its widespread adoption, the effectiveness of ND varies across urban and rural settings, influenced by disparities in transport times, EMS resources, and injury profiles.⁷ Rural areas, often marked by prolonged pre-hospital intervals, may experience heightened mortality risks, yet emerging evidence suggests adaptive EMS strategies could mitigate these challenges.³ The literature reveals inconsistent ND success rates, with studies reporting pleural access failures in up to 27.4% of cases and unnecessary procedures in 19%.⁸ Return of spontaneous circulation (ROSC) following ND has been documented at rates as high as 25%, indicating its potential efficacy.⁴ Rural trauma patients face elevated per capita mortality compared to urban counterparts, attributed to delayed diagnoses and variable provider training.⁷ These factors underscore the importance of ND in resource-limited settings where timely access to definitive care is constrained.³

This multi-center, retrospective study evaluates ND outcomes, positing that distinct injury patterns and EMS systems contribute to setting-specific results. By employing enhanced statistical techniques, it aims to provide actionable insights for clinical education and protocol development, addressing a critical gap in trauma care research.

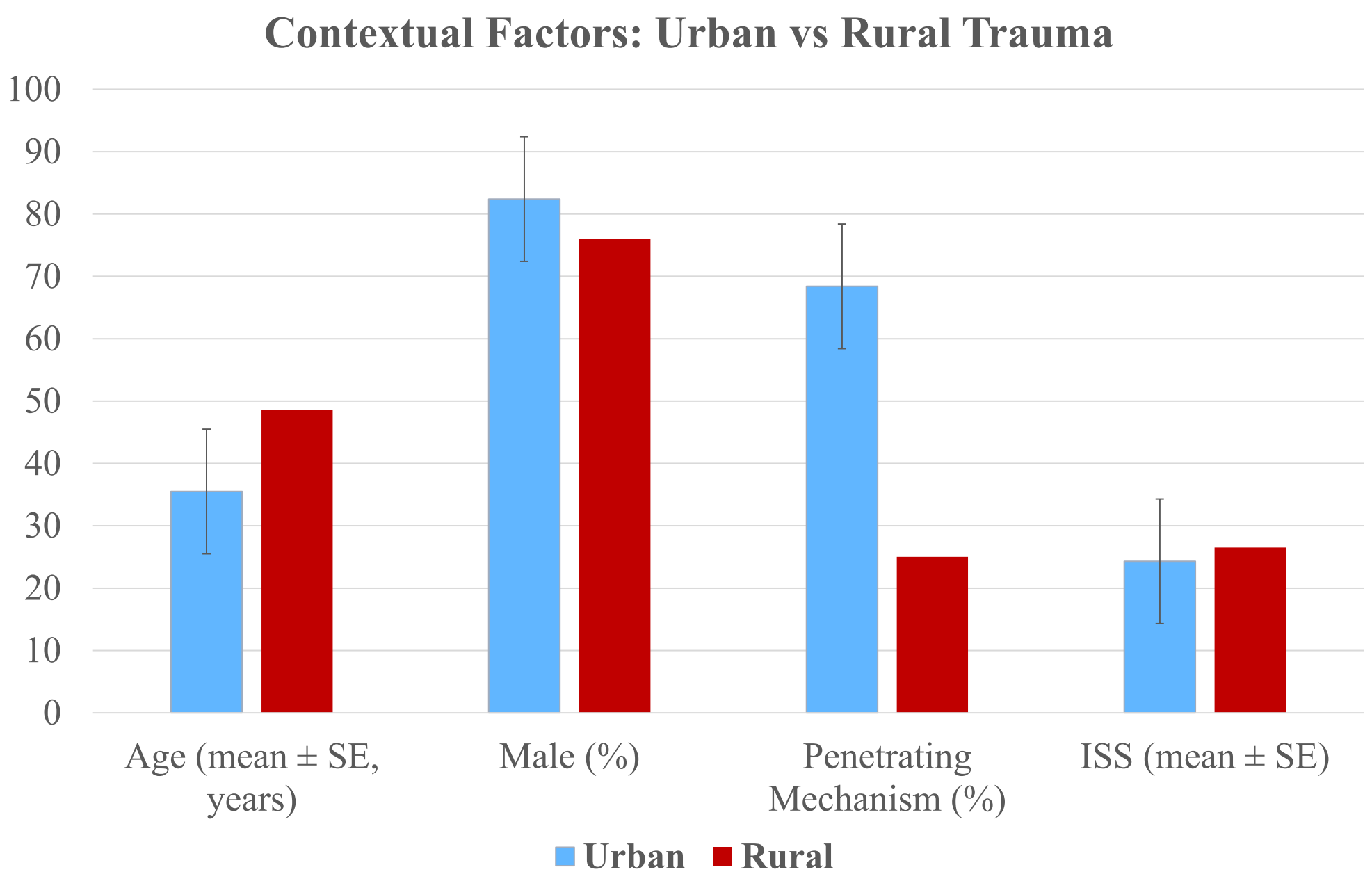
Methodology

Inclusion criteria encompassed adults (≥18 years) who underwent pre-hospital ND for suspected tension pneumothorax. Exclusion criteria included pediatric patients and records with missing or incomplete data (e.g., absent mortality status). ND procedures adhered to institution-specific EMS protocols, though precise laterality and anatomical site data were inconsistently recorded. Data collection included demographic variables age, gender, race, mechanism of injury [blunt vs. penetrating, ISS, pre-hospital metrics response time, on-scene time, transport time, vital signs systolic blood pressure (SBP), heart rate (HR), shock index (SI = HR/SBP)], pre-GCS, and procedures, and hospital outcomes (ED vital signs, disposition, LOS, mortality, ROSC [defined as ED-SBP > 0 following pre-hospital arrest. Statistical analyses followed STROBE guidelines for observational studies. Univariate comparisons utilized Student’s t-tests for continuous variables (reported as mean ± SE) and Fisher’s exact tests for categorical data.

Multivariate logistic regression modeled binary outcomes (mortality, pre-hospital cardiac arrest), adjusting for setting (urban=0, rural=1), age, ISS, mechanism (penetrating=1, blunt=0), transport time, pre-GCS, and on-scene time, with interaction terms (e.g.setting×mechanism) tested. Linear regression assessed LOS among survivors. Temporal trends were evaluated by dichotomizing data at 2015, reflecting potential EMS protocol shifts.¹ ND appropriateness was determined by the presence of pneumothorax diagnoses in 'DX' fields Data availability: De-identified datasets are available upon reasonable request, pending IRB approval.

Results

Demographics and Injury Information Urban patients were significantly younger and exhibited a higher prevalence of penetrating injuries, reflecting urban trauma epidemiology (Table 1).⁹

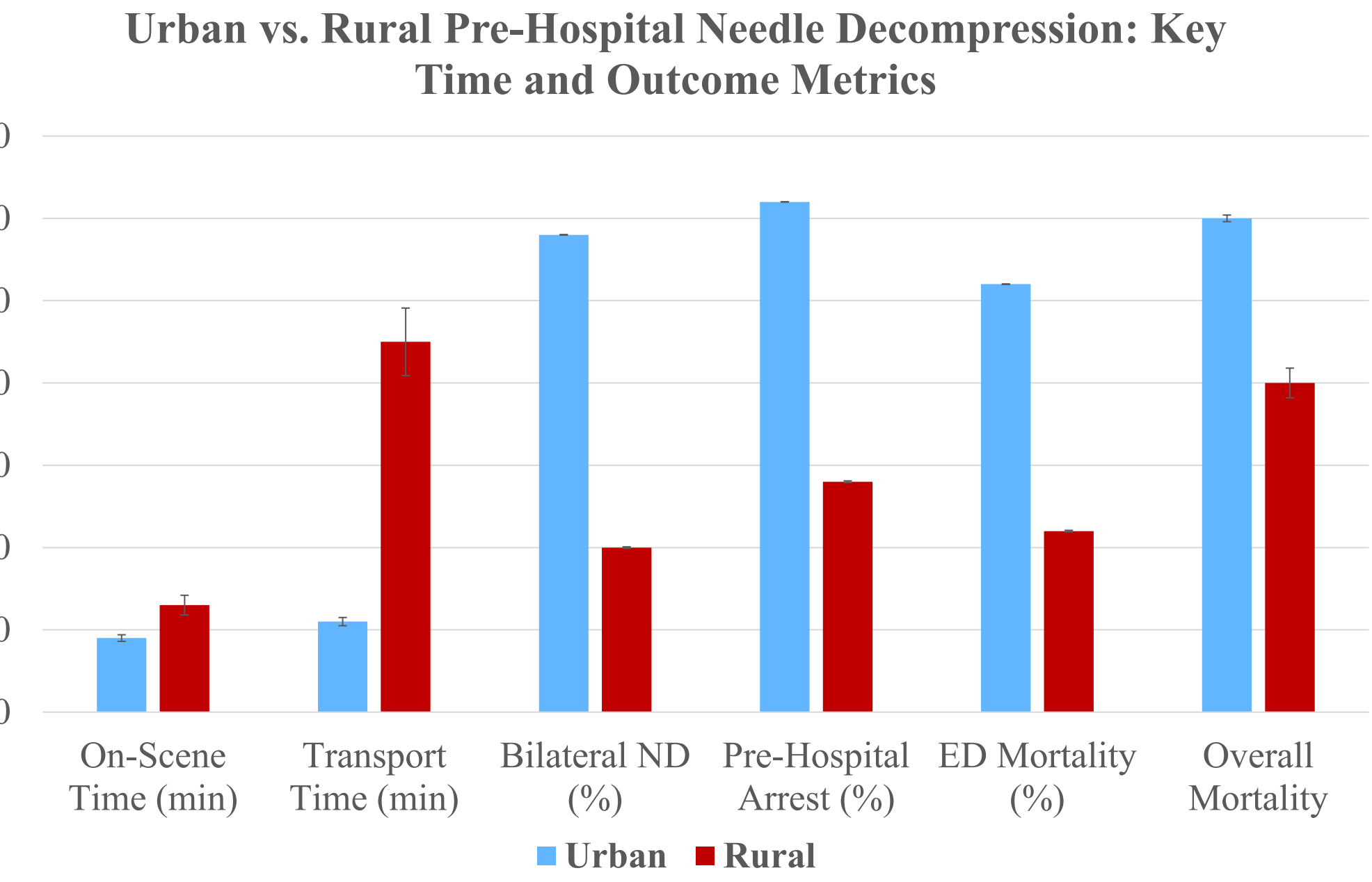


Characteristic	Urban (n=643)	Rural (n=59)	p-value
Age (mean ± SE, years)	35.5 ± 0.6	48.6 ± 2.2	<0.001
Male (%)	82.4	76.0	0.18
Penetrating Mechanism (%)	68.4	25.0	<0.001
ISS (mean ± SE)	24.3 ± 0.5	26.5 ± 1.7	0.12

Results

Overall mortality was significantly higher in urban settings (60% ± 2% vs 40% ± 6%, p=0.03), with ROSC rates of 38% in urban and 25% in rural patients. ND appropriateness, defined by confirmed pneumothorax diagnoses, was 75% in urban versus 85% in rural cases (p=0.09), aligning with reported failure rates.⁸

Metric	Urban (mean ± SE or %)	Rural (mean ± SE or %)	p-value
On-Scene Time (min)	9 ± 0.4	13 ± 1.2	<0.001
Transport Time (min)	11 ± 0.5	45 ± 4.1	<0.001
Bilateral ND (%)	58± 0.024	20± 0.097	0.003
Pre-Hospital Arrest (%)	62 ± 0.025	28 ± 0.097	0.002
ED Mortality (%)	52 ± 0.025	22 ± 0.10	0.004
LOS (days, mean ± SE)	5.9 ± 0.4	9.2 ± 1.8	0.32



Discussion

The expanded analysis reveals that rural patients exhibit lower mortality and pre-hospital cardiac arrest rates despite prolonged transport times, a finding substantiated by multivariate modeling that adjusts for injury severity and other confounders.²

The significant protective effect of rural setting (OR 0.23, p=0.016) suggests that adaptive EMS strategies, such as extended on-scene stabilization, may contribute to improved outcomes.²

Urban patients, predominantly affected by penetrating trauma, face elevated mortality (65% vs. 50% in rural penetrating cases, p=0.04), potentially linked to ND overuse or failure, as evidenced by a 27.4% failure rate in similar contexts.⁸ Temporal reductions in rural mortality post-2015 (OR 0.62, p=0.04) indicate possible benefits from enhanced EMS training or protocol adjustments.¹ The lack of a significant transport time effect (OR 1.00, p=0.44) contrasts with prior reports of a 2% mortality increase per minute, suggesting rural EMS may mitigate delays through effective on-scene interventions.¹¹ However, the higher urban mortality persists across ISS tertiles, underscoring setting-specific factors beyond severity.

Conclusion

This study highlights critical disparities in pre-hospital ND outcomes between urban and rural trauma patients. Rural patients benefit from lower mortality and cardiac arrest rates, likely due to effective on-scene EMS interventions despite prolonged transport times.

In contrast, urban patients, particularly those with penetrating trauma, face elevated mortality, suggesting potential ND inefficacy or overuse. These findings underscore the need for tailored EMS protocols, enhanced training, and prospective studies to optimize pre-hospital care across settings. By addressing these disparities, we can equip first responders to shine light on trauma care, improving outcomes for those who serve and protect the community.

Acknowledgements

- Aylwin CJ, Brohi K, Davies GD, Walsh MS. Pre-hospital and in-hospital thoracostomy: in dications and complications. *Ann R Coll Surg Engl.* 2008;90(1):54-57. doi:10.1308/003588408X242286
- Grossman, David C. MD, MPH; Kim, Allegra MS; Macdonald, Steven C. MPH, PhD; Klein, Pennie RN; Copass, Michael K. MD; Maier, Ronald V. MD. Urban-rural Differences in Prehospital Care of Major Trauma. The Journal of Trauma: Injury, Infection, and Critical Care 42(4):p 723-729, April 1997.
- Kong V, Sartorius B, Clarke D. Traumatic tension pneumothorax: experience from 115 consecutive patients in a trauma service in South Africa. *Eur J Trauma Emerg Surg.* 2016;42(1):55-59. doi:10.1007/s00068-015-0502-3
- Dickson RL, Gleisberg G, Aiken M, et al. Emergency Medical Services Simple Thoracostomy for Traumatic Cardiac Arrest: Postimplementation Experience in a Ground-based Suburban/Rural Emergency Medical Services Agency. *J Emerg Med.* 2018;55(3):366-371. doi:10.1016/j.jemermed.2018.05.027
- Rottenstreich M, Fay S, Gendler S, Klein Y, Arkovitz M, Rottenstreich A. Needle thoracotomy in trauma. *Military Medicine.* 2015;180(12):1211-1213. doi:10.7205/MILMED-D-14-00730
- Eckstein M, Suyehara D. Needle thoracostomy in the prehospital setting. *Prehosp Emerg Care.* 1998;2(2):132-135. doi:10.1080/10903129808958857

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