

ORIGINAL RESEARCH

Mechanical versus Manual Chest Compressions for Cardiopulmonary Resuscitation in Emergency Department: A Comparative Study

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Abstract: **Introduction:** Mechanical chest compression devices provide consistent depth and reduced pauses during cardiopulmonary resuscitation (CPR), but their clinical impact on routine practice in emergency department (ED) remains uncertain. This study aimed to compare the outcomes of mechanical versus manual compressions among adults with in-hospital cardiac arrest managed in ED. **Methods:** A single-center, comparative study of consecutive adult cardiac arrests in the ED (n = 372) was carried out. Patients were allocated by time period to either manual CPR (n = 195) during the retrospective phase (September 2024 to January 2025) or mechanical CPR (n = 177) with LUCAS-3 during the prospective phase (January to June 2025). The primary outcome was return of spontaneous circulation (ROSC). Secondary outcomes were survival at 6 hours and 24 hours post-arrest. Baseline differences were summarized with standardized mean differences, and survival was described with Kaplan-Meier curves (0-24 h). Logistic regression estimated odds ratios (ORs) for ROSC and 6-hour survival. **Results:** Mechanical and manual chest compression groups comprised 177 and 195 patients, respectively. Unadjusted outcomes favored mechanical CPR. ROSC occurred in 54 (30.5%) versus 32 (16.4%), with an absolute risk difference of 14.1% and Six-hour survival was 25 (14.1%) versus 5 (2.6%). After adjustment, mechanical CPR remained associated with higher odds of ROSC (OR = 2.44, 95% confidence interval (CI): 1.18-4.42) and 6-hour survival (OR = 6.71, 95% CI: 2.94-18.94). By 24 hours, no patient survived in the mechanical group, whereas one patient (0.5) survived in the manual group (P>0.05). Kaplan-Meier curves showed early separation that narrowed by 24 hours. **Conclusion:** It seems that mechanical chest compression during CPR is associated with increased ROSC and better early survival, compared to manual compression. Due to the limited sample size, non-randomized design with time-based allocation, single-center setting, potential residual confounding, and absence of neurologic outcomes, these results should be interpreted with caution.

Keywords: Cardiopulmonary Resuscitation; Heart Arrest; Emergency Service, Hospital; Survival Rate

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1. Introduction

In-hospital cardiac arrest (IHCA) remains a major worldwide public health problem, and survival to discharge rates remain low despite new resuscitation protocols. Chest compression quality, adequate depth, rate, and minimum interruption are important discriminators of successful cardiopulmonary resuscitation (CPR) and are featured in American Heart Association (AHA) and European Resuscitation Council (ERC) guidelines (1, 2). Improving compression quality in practice, nevertheless, is compromised by rescuer fatigue, technical heterogeneity, and operational interruption (3).

Mechanical chest compression devices (MCCDs) were created to compensate for these deficiencies with the provision of automated, reproducible compression at defined guideline parameters. MCCDs are strongly supported in situations where compression through manual methods becomes unsustainable, like during the transportation of the patient, prolonged resuscitation, or concurrent procedures (4, 5). Theoretical advantages of MCCDs include improved hemodynamic parameters, less variability, and decreased compression pause.

Yet, clinical trials so far are inconclusive. Several randomized trials and meta-analyses have produced conflicting evidence to prove the superiority of MCCDs over high-quality manual CPR on primary end points of ROSC, discharge survival, or good neurologic function (6-9). Some analyses show identical endpoints between methods, others show possible differences at intermediate endpoints, but frequently, results are biased due to variation of study design, device type, and de-

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ployment interval (8, 9). Increased rates of rib fracture and visceral injury have been reported in association with mechanical devices (10).

Most high-quality evidence stems from out-of-hospital cardiac arrest (OHCA) environments, which were not found to demonstrate a survival benefit of MCCDs compared to manual compressions in large randomized clinical trials (RCTs) like PARAMEDIC and LINC (6, 7). Conversely, in the hospital, especially in the emergency department (ED), evidence is limited and typically based on single-center observational reports or registry analysis. Result have been neutral to possibly favorable for mechanical CPR (11, 12).

Furthermore, since the majority of literature to date has emanated from high-resource EDs, little is known of their contribution to middle-income EDs in which overcrowding and inadequate staff levels could offset any advantage that would be expected. This study sought to contrast the mechanical and manual chest compression outcomes of ED-managed IHCA in a tertiary teaching hospital in Tehran, Iran.

2. Methods

2.1. Study design and setting

This was a single-center comparative study conducted in two sequential, time-defined phases following the introduction of the LUCAS-3 device. All eligible cases in the retrospective phase (September 2024 to January 2025) received manual chest compressions, while all eligible cases in the prospective phase (January to June 2025) received mechanical chest compressions with LUCAS-3 (Stryker Corp., Portage, MI, USA), barring the study's exclusion criteria. Allocation was therefore strictly time-based rather than operator-preference.

2.2. Ethical considerations

The Research Ethics Committees of the School of Medicine of Shahid Beheshti University of Medical Sciences approved the study (IR.SBMU.MSPREC.1404.051).

2.3. Participants

Adult patients (Age ≥ 18 years) with documented IHCA occurring in the ED and complete documentation of resuscitation parameters were included. Age < 18 years, incomplete or missing key clinical data, cardiac arrest due to traumatic causes, anatomical limitations preventing device application (e.g., chest circumference > 129 cm, severe spinal deformity), and known pregnancy, were among the exclusion criteria. A consecutive sampling approach was used for both phases.

2.4. Data gathering

Demographics, comorbidities, and pre-arrest vital signs were recorded at the ED. The Acute Physiology and Chronic Health Evaluation II (APACHE II) and Sequential Organ Failure Assessment (SOFA) scores were calculated from the available ED parameters. Cardiac arrest characteristics, such as time of

arrest, initial rhythm (shockable or non-shockable), and possible cause of arrest, were also recorded. Moreover, CPR process metrics, including CPR method (manual vs mechanical), time to CPR initiation, duration of each CPR attempt, number of CPR cycles, depth and rate of compressions, compression flow fraction (proportion of time with active compressions), total number of compressions, pause intervals, defibrillation attempts, and resuscitation drug administration were recorded using a predesigned check list for each patient. Retrospective data were extracted from electronic medical records (EMRs), paper charts, and resuscitation logs by two independent reviewers using a standardized form. Prospective data were recorded in real time by trained staff. Collected variables included demographics and comorbidities, arrest characteristics, CPR process metrics, and outcomes as defined above. Discrepancies were resolved by consensus. Abbas Hasanzadeh was responsible for data gathering.

2.5. Interventions

Manual CPR was performed by medical interns and residents under continuous supervision of an emergency medicine attending physician following the 2020 AHA and 2021 ERC guidelines. Briefly, compression rate was set to 100-120 per minute, depth of 5-6 cm (2 inches), complete recoil, and minimal interruptions, with rescuer rotations every 2 minutes. It is noteworthy that all providers had completed formal advanced life support (ALS) training prior to their participation in the study. Mechanical CPR used a piston-driven LUCAS-3 (Stryker Corp., Portage, MI, USA), applied by trained staff with a target application pause < 20 seconds. Thus, manual compression was not performed prior to the use of the mechanical device. Compression parameters followed manufacturer specifications aligned with AHA/ERC recommendations.

2.6. Outcomes

The primary outcome was ROSC, defined as sustained palpable pulse and measurable blood pressure for at least 20 minutes without ongoing compressions. Secondary outcomes included survival at 6 and 24 hours post-arrest, and duration of the initial CPR attempt.

2.7. Statistical analysis

A total of 372 adult patients with documented IHCA in the ED were included and grouped into manual ($n = 195$) and mechanical CPR ($n = 177$), using a consecutive sampling approach for both phases.

Analyses were performed using IBM SPSS Statistics v. 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean \pm standard deviation (SD) and categorical variables as frequency (%). Standardized mean differences (SMDs) were examined to assess comparability across groups. Between-group comparisons used Student's t-tests or Mann-Whitney U tests for continuous variables, and chi-square or Fisher's exact tests for categorical variables. Mul-

tivariable logistic regression estimated the association between CPR method and outcomes (ROSC, 6-hour survival), with APACHE II score, absence of sepsis, and initial shockable rhythm as covariates. Kaplan-Meier curves and log-rank tests compared survival distributions. Cox proportional hazards models provided hazard ratios (HRs) for mortality, with proportionality checked via Schoenfeld residuals. A p -value < 0.05 was considered statistically significant.

3. Results

3.1. Participant flow and baseline

A total of 372 patients were included, 195 in the manual and 177 in the mechanical chest compression. The study flow is shown in Figure 1. The mean age of included patients was 68.5 ± 14.9 (range: 18-105) years (69.3 ± 13.9 years in the manual group and 67.5 ± 15.9 years in the mechanical group; $p = 0.235$). The proportion of males was slightly higher in the mechanical group (61.6% vs 56.9%, $p = 0.340$). Table 1 compares the baseline characteristics of patients between manual and mechanical chest compression groups.

The mean APACHE II score was significantly higher in the mechanical group (22.98 ± 6.83 vs. 19.97 ± 6.26 ; $p < 0.001$). SOFA scores did not differ significantly between groups ($p = 0.115$).

The prevalence of hypertension ($p = 0.285$), diabetes mellitus ($p = 0.802$), ischemic heart disease ($p = 0.564$), and malignancy ($p = 0.210$) was similar in both groups. Sepsis at presentation was more common in the manual group (27.2% vs 11.3%; $p = 0.002$).

Arterial oxygen partial pressure (PaO₂) was significantly greater in the mechanical group compared with the manual group (79.36 ± 10.04 vs 60.28 ± 17.01 mmHg, $p < 0.001$). Glasgow Coma Scale (GCS) scores before arrest were lower in the mechanical versus the manual group (3.98 ± 2.23 vs 5.66 ± 2.92 , $p < 0.001$).

For the baseline laboratory findings, many were almost similar. However, C-reactive Protein (CRP) (193.12 ± 27.50 vs 164.32 ± 49.81 mg/dL, $p = 0.008$) and N-terminal Pro B-type Natriuretic Peptide (NT-proBNP) (17830.00 ± 7988.79 vs 10178.96 ± 10700.80 ng/mL, $p = 0.041$) were higher in the manual group. Baseline imbalances are visualized in Figure 2A, with the largest SMDs for PaO₂, NT-proBNP, CRP, and GCS.

3.2. Arrest characteristics and CPR process

The median duration of the initial CPR cycle was longer in the mechanical than in the manual group (34.20 ± 10.73 vs. 31.55 ± 10.55 minutes, $p = 0.017$). The need for a second CPR cycle was more frequent with mechanical compressions (52.0% vs 15.4%, OR = 7.07, 95% confidence interval (CI): 4.30-11.62, $p < 0.001$). Administration of resuscitation drugs was largely similar between groups, though sodium bicarbonate use was more frequent in the mechanical group (4.5% vs 1.0%, OR = 4.38, 95% CI: 1.05-18.38, $p = 0.03$) (Table 2).

3.3. Primary and secondary outcomes

ROSC occurred in 54 (30.5) patients receiving mechanical chest compression versus 32 (16.4) patients receiving manual CPR (OR = 2.22, 95% CI: 1.36-3.64, $p < 0.001$). Six-hour survival was higher in the mechanical group (14.1% vs 2.6%, OR = 5.29, 95% CI: 2.35-11.90, $p < 0.001$). Survival at 24 hours was rare and not significantly different between groups (0% mechanical vs 0.5% manual, OR = 0.37, 95% CI: 0.01-9.02, $p = 1.00$) (Table 3).

3.4. Multivariable analysis

After adjusting for APACHE II score, sepsis, and initial shockable rhythm, mechanical CPR was independently associated with higher odds of ROSC (adjusted OR = 2.44, 95% CI: 1.18-4.42, $p = 0.01$) (Figure 2B) and 6-hour survival (adjusted OR = 6.71, 95% CI: 2.94-18.94, $p < 0.001$) (Figure 2C). No independent association was found for 24-hour survival.

3.5. Survival analysis

Kaplan-Meier curves showed early separation favoring mechanical CPR from 30 minutes to 12 hours after arrest (log-rank $p < 0.001$), but survival curves converged by 24 hours. Cox proportional hazards analysis demonstrated a 54% relative reduction in mortality within the first 12 hours for the mechanical group (HR = 0.46, 95% CI: 0.35-0.61, $p < 0.001$) (Figure 2D).

3.6. Subgroup analysis

Benefits were concentrated among patients with lower illness severity (APACHE II ≤ 24 : ROSC OR = 4.23, 95% CI: 2.32-7.72; 6-h OR = 15.70, 95% CI: 4.10-59.70), with no clear advantage at higher severity (APACHE II > 24 : ROSC OR = 0.59, 95% CI: 0.24-1.46; 6-h OR = 0.59, 95% CI: 0.15-2.24). Effects were also present among those without sepsis (ROSC OR = 2.25, 95% CI: 1.29-3.93; 6-h OR = 9.80, 95% CI: 2.60-36.90) and with non-shockable rhythms (ROSC OR = 2.19, 95% CI: 1.33-3.60; 6-h OR = 5.44, 95% CI: 2.10-14.12) (Table 4).

4. Discussion

In this comparative study, conducted in a tertiary hospital emergency department, MCCDs were found to significantly improve short-term survival (up to 6 hours) and the likelihood of ROSC in IHCA, even after controlling for important confounders like initial rhythm, sepsis, and severity of disease based on APACHE II score. The separation of Kaplan-Meier curves showed that mechanical CPR may improve early physiologic endpoints such as ROSC and 6-hour survival. Nevertheless, these gains did not translate into survival beyond 24 hours in the mechanical group. Possible explanations include time-based allocation with evolving processes of care, deployment, and transition intervals that could offset benefits, case-mix differences not fully captured by adjustment, and variability in post-ROSC care (hemodynamics, ventilation, and temperature control).

Large international randomized controlled trials on OHCA cases, such as the PARAMEDIC (6) and LINC (7), have similarly reported no survival-to-discharge benefit with mechanical devices versus high-quality manual CPR. Differences in setting, staffing, and post-arrest bundles between our tertiary ED and those trials may contribute to divergent early endpoints.

For IHCA, the evidence base is smaller but more nuanced. Couper et al. (4) found that MCCDs during IHCA may improve ROSC, but heterogeneity in study designs and device protocols limited the certainty of evidence. In a single-center Turkish ED study, Şener et al. (12) demonstrated higher seven-day survival with MCCDs. Crowley et al. (11) found improved ROSC and in-hospital survival using multicenter registry data, but selection bias and protocol variability were likely to introduce confounding.

Global pooled analyses such as Liu et al. (13) and a Cochrane review by Brooks & Wang (14) confirm a recurring theme: MCCDs consistently increase ROSC rates, but their effects on neurological recovery or long-term survival are not always consistent. This supports the early but short-lived benefit we found. Our contribution is relevant to regional and global discussions because ED-based IHCA has not been extensively studied in the past.

The 2020 AHA guidelines (2) and the 2021 ERC guidelines (1) emphasize the importance of performing high-quality chest compressions for successful resuscitation. Although manual compressions are effective when performed correctly, rescuer fatigue and the need to rotate every two minutes can cause them to deteriorate in quality rapidly (15, 16). The chest compression fraction is lowered, and the perfusion of the heart and brain is compromised by even brief stops for defibrillation, ventilation, or rhythm checks.

MCCDs offered several physiological and functional advantages, such as reaching the targeted depth and pace without allowing technique drift or weariness to get in the way, allowing continuous compressions during airway interventions or patient transfers, and improving hemodynamics through producing longer-lasting elevated coronary perfusion pressures in comparison to manual CPR in a pig model (17).

Our finding that the mechanical group had longer CPR cycles but produced better early results supports the idea that compression quality, not just duration, is important. Nonetheless, these differences likely reflect confounding by indication, indicating that mechanical devices were preferentially used when prolonged CPR was anticipated. Hence, MCCDs may be especially helpful for patients who need complex resuscitation techniques, where maintaining continuous compressions by hand can be logistically difficult.

In middle-income healthcare systems like Iran, emergency departments often face high patient volumes, limited staffing flexibility, and uneven access to advanced post-arrest care. MCCDs may offer a helpful operational buffer in these circumstances, ensuring compression quality when staffing ratios are not optimal or when trained personnel must perform

concurrent interventions. Because manual CPR quality depends on the operator and human factors, MCCDs can standardize performance across shifts and provider skill levels. This standardization is particularly useful in academic hospitals where resuscitation teams include trainees.

However, structural limitations beyond initial resuscitation are highlighted by our lack of long-term survival benefit. Numerous factors, such as the intensive care unit's limited capacity, the inconsistent implementation of targeted temperature management, and the lack or postponement of advanced hemodynamic monitoring, likely contributed to the rapid attrition in survival after the 12-hour mark. Since similar limitations have been found in other middle-income studies, it is important to think of MCCDs as a single component of a larger resuscitation and post-resuscitation system. We did not systematically assess CPR-related injuries. Yet, Gao et al. (10) reported higher incidences of rib and sternal fractures and occasional visceral injuries with MCCDs compared to manual CPR. Since many resuscitated patients in our setting do not receive post-mortem imaging or examination, subclinical injuries may have gone undetected. This highlights the importance of weighing the benefits of mechanical CPR against any potential risks, especially when performing prolonged resuscitation.

5. Limitations

Limitations of this study included a limited sample size and event counts, a non-randomized, sequential, time-based allocation (risk of temporal confounding), a lack of a standardized post-resuscitation care protocol, the absence of neurologic outcome data, and no systematic injury surveillance.

We suggest that a multicenter randomized controlled trial in ED-based IHCA populations should be performed, measuring long-term neurological outcomes and incorporating standardized post-arrest care protocols.

6. Conclusions

Mechanical CPR improved ROSC and early survival without extending survival beyond 24 hours. It is necessary to conduct randomized, multicenter studies with neurologic endpoints and standardized post-ROSC care to determine meaningful patient-centered benefit.

7. Declarations

7.1. Acknowledgments

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7.2. Author contributions

Ali Vafaei: investigation, writing - original draft preparation. Parvin Kashani: investigation, writing - original draft preparation, Writing - review and editing. Amir Heidari: investiga-

tion, writing - original draft preparation. Abbas Hasanzadeh: investigation, writing - original draft preparation. Soheil Ebrahimpour: investigation, supervision, writing - original draft preparation. All authors contributed significantly to the work and approved the final version of the manuscript. Their contributions align with the latest guidelines of the International Committee of Medical Journal Editors (ICMJE). All authors read and approved the final version of manuscript.

7.3. Ethics approval statement

The Research Ethics Committees of the School of Medicine of Shahid Beheshti University of Medical Sciences approved the study (IR.SBMU.MSPREC.1404.051).

7.4. Patient consent statement

Informed consent was obtained from all study participants.

7.5. Conflicts of interest disclosures

The authors declare no conflicts of interest.

7.6. Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

7.7. Using artificial intelligence chatbots

Generative AI (ChatGPT) was used solely for English language editing (grammar, clarity, and formatting) of author-written text. The authors verified all content, are responsible for the final text, and ensured no confidential, identifiable, or proprietary data was shared with the tool.

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Table 1: Baseline characteristics of study participants

Variable	Overall	Chest compression method		SMD*	p-value
		Manual	Mechanical		
Age, years	68.50 ± 14.89	69.38 ± 13.87	67.54 ± 15.93	-0.12	0.235
SBP, mmHg	67.25 ± 50.69	62.52 ± 49.59	72.45 ± 51.52	0.20	0.042
DBP, mmHg	44.68 ± 33.63	42.49 ± 33.66	47.09 ± 33.53	0.14	0.187
MAP, mmHg	52.20 ± 38.90	49.17 ± 38.50	55.55 ± 39.19	0.16	0.371
HR, bpm	104.80 ± 19.86	106.33 ± 17.53	103.29 ± 23.57	-0.15	0.244
RR, breaths/min	25.07 ± 9.78	25.63 ± 5.63	25.39 ± 12.46	-0.03	0.844
PaO ₂ , mmHg	69.53 ± 16.99	60.28 ± 17.01	79.36 ± 10.04	1.35	< 0.001
pH	7.20 ± 0.21	7.21 ± 0.22	7.18 ± 0.20	-0.14	0.273
WBC, ×10 ⁹ /L	13.20 ± 11.21	14.35 ± 13.25	12.09 ± 8.71	-0.20	0.823
Platelets, ×10 ⁹ /L	210.10 ± 129.78	218.39 ± 124.27	206.82 ± 132.37	-0.09	0.465
HCT, %	34.43 ± 9.02	35.29 ± 9.28	33.95 ± 8.81	-0.15	0.225
Total bilirubin, mg/dL	2.31 ± 2.42	2.65 ± 2.95	1.97 ± 1.70	-0.28	0.565
Sodium, mEq/L	137.64 ± 11.57	139.61 ± 9.76	136.24 ± 12.12	-0.31	0.013
Potassium, mEq/L	4.66 ± 1.09	4.61 ± 1.06	4.75 ± 1.15	0.13	0.280
Creatinine, mg/dL	2.76 ± 2.62	2.74 ± 2.73	2.72 ± 2.51	-0.01	0.967
CRP, mg/dL	175.28 ± 43.49	164.32 ± 49.81	193.12 ± 27.50	0.64	0.008
D-dimer, ng/mL	3445.00 ± 1167.84	3773.40 ± 1531.55	3073.94 ± 589.66	-0.50	0.007
NT-proBNP, ng/mL	15710.80 ± 10489.22	10178.96 ± 10700.80	17830.00 ± 7988.79	0.76	0.041
GCS	5.60 ± 2.93	5.66 ± 2.92	3.98 ± 2.23	-0.64	< 0.001
APACHE II	21.40 ± 6.70	19.97 ± 6.26	22.98 ± 6.83	0.46	< 0.001
SOFA	9.02 ± 2.68	8.81 ± 2.74	9.25 ± 2.60	0.16	0.115
DHF	80 (21.5)	49 (25.1)	31 (17.5)	-0.12	0.272
Diabetes	75 (20.2)	41 (21.0)	34 (19.2)	0.03	0.802
HTN	79 (21.2)	40 (20.5)	39 (22.0)	0.12	0.285
Pulmonary diseases	32 (8.6)	15 (7.7)	17 (9.6)	0.12	0.280
Smoking history	19 (5.1)	3 (1.5)	16 (9.0)	0.41	< 0.001
Neurological diseases	29 (7.8)	18 (9.2)	11 (6.2)	-0.06	0.567
LOC	253 (68.0)	153 (78.5)	100 (56.5)	-0.41	< 0.001
Brain hemorrhage	8 (2.2)	2 (1.0)	6 (3.4)	0.20	0.091
HLP	3 (0.8)	1 (0.5)	2 (1.1)	0.09	0.409
CKD	33 (8.9)	19 (9.7)	14 (7.9)	-0.02	0.874
CVA	35 (9.4)	19 (9.7)	16 (9.0)	0.04	0.755
Cardiac diseases	19 (5.1)	12 (6.2)	7 (4.0)	-0.06	0.564
DKA	11 (3.0)	4 (2.1)	7 (4.0)	0.15	0.195
Asthma	2 (0.5)	1 (0.5)	1 (0.6)	0.02	0.847
Uremia	18 (4.8)	5 (2.6)	13 (7.3)	0.28	0.018
PTE	11 (3.0)	6 (3.1)	5 (2.8)	0.02	0.880
DVT	3 (0.8)	0 (0)	3 (1.7)	0.22	0.083
DIC	1 (0.3)	1 (0.5)	0 (0)	-0.10	0.384
Sepsis	73 (19.6)	53 (27.2)	20 (11.3)	-0.35	0.001
HIV	3 (0.8)	0 (0)	3 (1.7)	0.22	0.083
TB	9 (2.4)	1 (0.5)	8 (4.5)	0.30	0.013
GIB	22 (5.9)	9 (4.6)	13 (7.3)	0.17	0.137
Malignancy	75 (20.2)	37 (19.0)	38 (21.5)	0.14	0.210
Cirrhosis	7 (1.9)	1 (0.5)	6 (3.4)	0.25	0.040

Data are presented as mean ± standard deviation or frequency (%). * Positive SMDs indicate a higher effect in the mechanical chest compression group. SMD: Standardized Mean Difference; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; MAP: Mean Arterial Pressure; HR: Heart Rate; RR: Respiratory Rate; PaO₂: Arterial Oxygen Partial Pressure; WBC: White Blood Cell; HCT: Hematocrit; CRP: C-reactive Protein; NT-proBNP: N-terminal Pro B-type Natriuretic Peptide; GCS: Glasgow Coma Scale; SOFA: Sequential Organ Failure Assessment; APACHE II: Acute Physiology and Chronic Health Evaluation II; DHF: Decompensated Heart Failure; HTN: Hypertension; LOC: Level of Consciousness; HLP: Hyperlipoproteinemia; CKD: Chronic Kidney Disease; CVA: Cerebrovascular Accident; DKA: Diabetic Ketoacidosis; PTE: Pulmonary Thromboembolism; DVT: Deep Vein Thrombosis; DIC: Disseminated Intravascular Coagulation; HIV: Human Immunodeficiency Virus; TB: Tuberculosis; GIB: Gastrointestinal Bleeding.

Table 2: Cardiopulmonary resuscitation process indicators in the two groups

Metric	Compression method		SMD*	p-value
	Manual	Mechanical		
First CPR duration, minutes	31.55 ± 10.55	34.20 ± 10.73	0.25	0.017
Time between first and second CPR, minutes	165.33 ± 202.28	179.62 ± 180.98	0.08	0.716
History of prior CPR	21 (10.8)	28 (15.8)	0.18	0.100
Epinephrine administered	195 (100)	177 (100.0)	0	0.918
Second CPR cycle indicated	30 (15.4)	92 (52.0)	0.97	< 0.001
Third CPR cycle indicated	1 (0.5)	3 (1.7)	0.14	0.236
Fourth CPR cycle indicated	1 (0.5)	0 (0.0)	-0.10	0.384

Data are presented as mean ± standard deviation or frequency (%). * Positive SMDs indicate a higher effect in the mechanical CPR group. SMD: Standardized Mean Difference; CPR: Cardiopulmonary Resuscitation.

Table 3: Outcome indices by different methods of CPR in the two groups

Time point	Compression method		RD	OR*	95% CI	p-value	NNT
	Manual	Mechanical					
ROSC	32 (16.4)	54 (30.5)	14.1	2.22	1.36-3.64	< 0.001	8
30 min survival	86 (44.1)	128 (72.3)	28.2	3.31	2.15-5.11	< 0.001	4
1-h survival	31 (15.9)	86 (48.6)	32.7	5.00	3.08-8.11	< 0.001	4
2-h survival	16 (8.2)	47 (26.6)	18.3	4.04	2.20-7.45	< 0.001	6
6-h survival	5 (2.6)	25 (14.1)	11.6	5.29	2.35-11.90	< 0.001	9
12-h survival	1 (0.5)	7 (4.0)	3.4	7.99	0.97-65.59	0.053	30
24-h survival	1 (0.5)	0 (0)	-0.5	0.37	0.01-9.02	1.00	-

Data are presented as frequency (%). *: Unadjusted. RD: Risk difference; OR: Odds Ratio; CI: Confidence Interval; NNT: Number-Needed-to-Treat; ROSC: Return of Spontaneous Circulation.

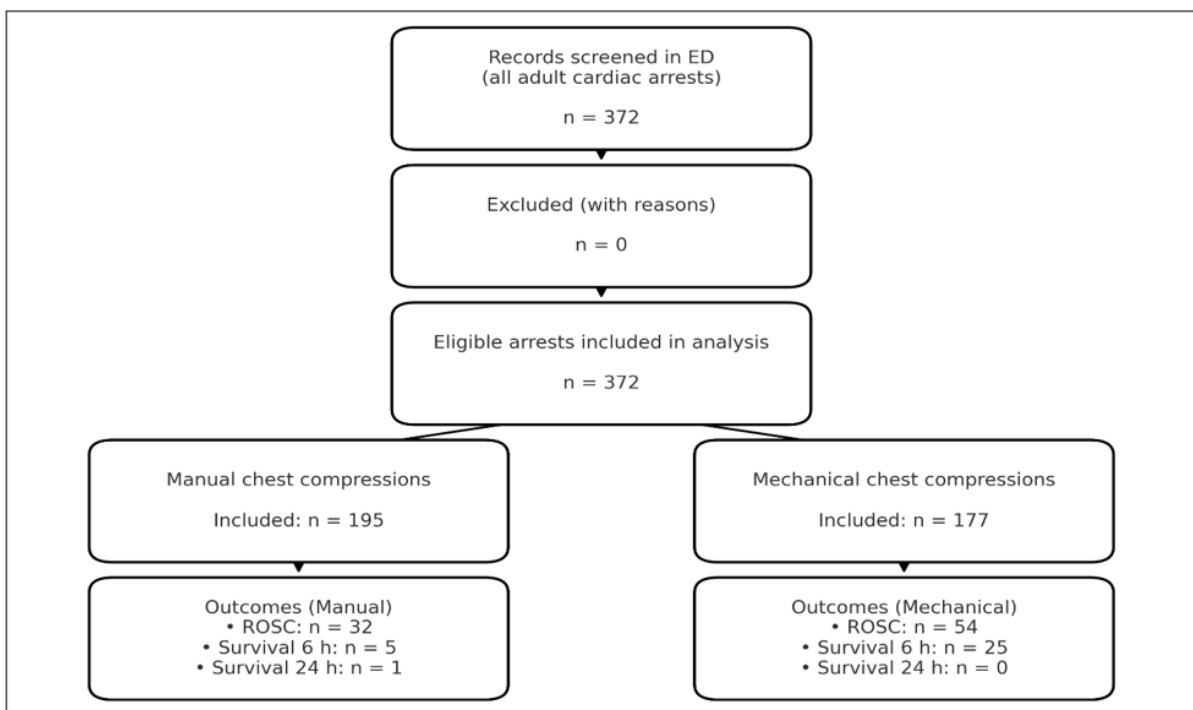


Figure 1: STROBE flow diagram of case selection and group allocation. All adult patients experiencing in-hospital cardiac arrest (IHCA) in the emergency department (ED) during the study period were screened (n = 372). No cases met the exclusion criteria. The manual chest compression group included 195 patients, whereas the mechanical chest compression device (MCCD) group included 177 patients. This flow diagram details screening, exclusions, and allocation to manual vs mechanical groups. ROSC: return of spontaneous circulation.

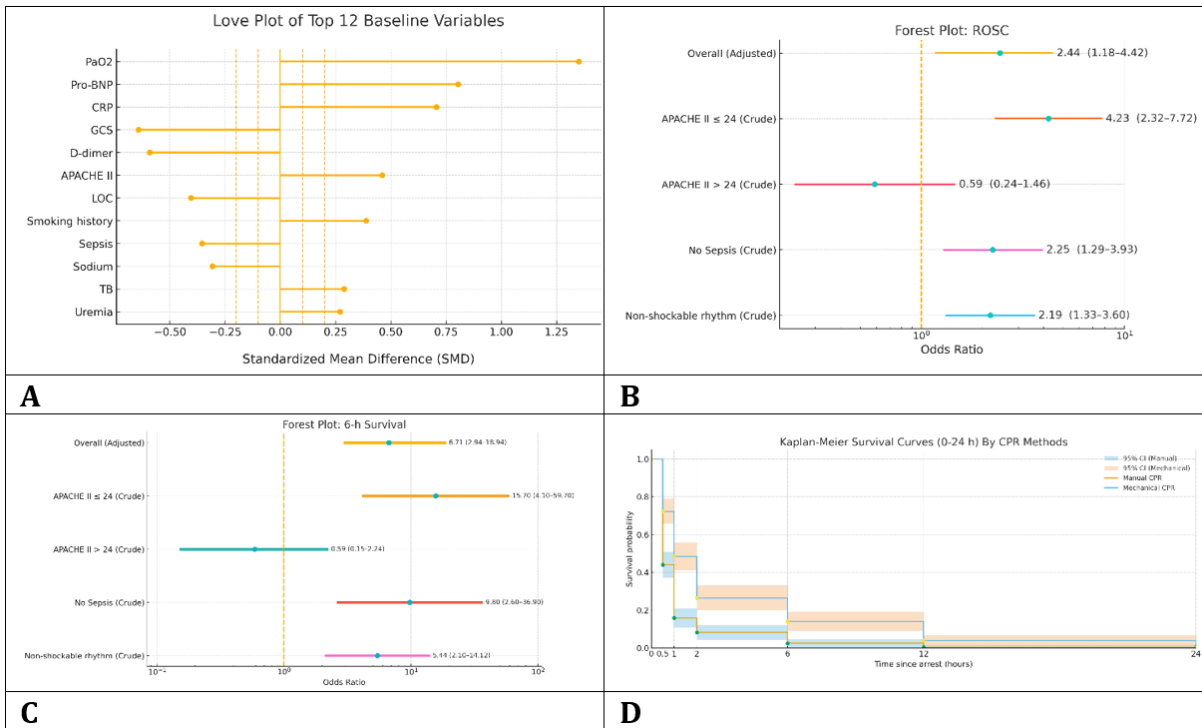


Figure 2: A: Love plot showing standardized mean differences (SMD) for the top 12 baseline variables between the manual and mechanical groups. Variables include Partial Pressure of Arterial Oxygen (PaO), pro-B-type Natriuretic Peptide (pro-BNP), C-reactive protein (CRP), Glasgow Coma Scale (GCS), D-dimer, Acute Physiology and Chronic Health Evaluation II (APACHE II), level of consciousness (LOC), smoking history, sepsis, serum sodium, tuberculosis (TB), and uremia. Dashed lines indicate conventional thresholds for SMD balance. B: Forest plot showing odds ratios for return of spontaneous circulation (ROSC) across the overall adjusted model and key subgroups. Mechanical Cardiopulmonary Resuscitation (CPR) was associated with higher odds of ROSC in the overall model and patients with APACHE II scores ≤ 24, absence of sepsis, and non-shockable rhythms. C: Forest plot showing odds ratios for six-hour survival across the overall adjusted model and key subgroups. Mechanical Cardiopulmonary Resuscitation (CPR) was associated with substantially higher odds of survival in the overall model and most subgroups, except for patients with APACHE II scores > 24, where no significant benefit was observed. D: Kaplan-Meier survival curves comparing mechanical and manual chest compressions over the first 24 hours. Survival probabilities diverged early, with mechanical Cardiopulmonary Resuscitation (CPR) showing higher short-term survival up to approximately 12 hours, after which the curves converged. Shaded bands denote 95% confidence intervals (CIs) calculated using Greenwood's formula.