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# Real-time Chest Compression Feedback Devices for Cardiopulmonary Resuscitation and Outcomes in Patients with Cardiac Arrest: A Meta-Analysis

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**ADMINISTRATIVE INFORMATION**

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**Conflicts of interest -** None declared.

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**Amendments -** This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 20 November 2026 and was last updated on 20 November 2026.

## INTRODUCTION

**Review question / Objective** Objective: To evaluate whether real-time chest-compression feedback devices during cardiopulmonary resuscitation (CPR) improve clinical outcomes among adult cardiac-arrest patients.

PICOS

- Population: Adult patients (≥18 years) experiencing in-hospital (IHCA) or out-of-hospital cardiac arrest (OHCA).
- Intervention: CPR performed with real-time chest-compression feedback devices (defibrillator-integrated audiovisual systems, standalone mechanical-tactile devices, or audio-only metronome-type prompts).
- Comparison: Standard CPR without real-time compression feedback.
- Outcomes: Primary-return of spontaneous circulation (ROSC); Secondary-survival to hospital discharge, 7-day survival, 30-day survival.
- Study design: Randomised controlled trials, cluster-randomised trials, prospective/retrospective cohort, before-after and prospective interventional comparative studies.

Review question: Among adult patients with in-hospital or out-of-hospital cardiac arrest, does use of real-time chest-compression feedback devices during CPR, compared with standard CPR without real-time feedback, increase the odds of ROSC and short-to-medium-term survival, and do patient age, arrest location or feedback-device type modify these clinical effects?

**Condition being studied** Cardiac arrest describes the abrupt cessation of effective cardiac mechanical activity, leading to loss of consciousness, absent pulse and circulatory collapse, which constitutes a life-threatening medical emergency. It is categorised as out-of-hospital cardiac arrest (OHCA) when it occurs

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outside medical facilities and in-hospital cardiac arrest (IHCA) when it arises within healthcare settings.

Globally, cardiac arrest imposes substantial public-health burden. For OHCA treated by emergency medical services (EMS), the reported annual incidence in Europe is approximately 55 per 100 000 population, and overall survival remains persistently low worldwide. Survival chances depend heavily on the chain of survival: prompt recognition, bystander cardiopulmonary resuscitation (CPR), early defibrillation, advanced emergency care and post-arrest intensive management.

High-quality CPR — with adequate compression depth, optimal compression rate, full chest wall recoil and minimal interruptions — is a core determinant of resuscitation success. Poor-quality CPR is common in real-world clinical practice despite formal resuscitation training, and it reduces the probability of return of spontaneous circulation (ROSC) and subsequent survival.

ROSC, the restoration of spontaneous systemic circulation, represents the key immediate physiological marker of successful resuscitation. Even when ROSC is achieved, patients still face high risks of multi-organ injury, hypoxic-ischaemic brain damage and early death. Longer-term patient-centred outcomes include survival to hospital discharge, 7-day and 30-day survival; ideally, survival with favourable neurological status. Real-time chest-compression feedback devices are technological tools intended to correct rescuer performance and boost CPR quality, yet their capacity to translate quality improvements into tangible patient-level clinical benefits remains uncertain.

## METHODS

**Participant or population** This review included adult patients aged 18 years or older who experienced cardiac arrest, encompassing both out-of-hospital cardiac arrest (OHCA) and in-hospital cardiac arrest (IHCA). No restrictions were applied regarding initial arrest rhythm or presumed underlying aetiology of cardiac arrest.

Excluded populations were paediatric participants (<18 years) without separable adult-only data, patients with traumatic cardiac arrest, and individuals with pre-existing do-not-resuscitate orders.

Study participants were patients receiving resuscitation from professional rescuers, including emergency medical services personnel, physicians, and nurses. Only human clinical study populations were eligible; manikin-simulation subjects and animal experimental subjects were excluded.

**Intervention** The intervention under evaluation was use of real-time chest-compression feedback devices during active cardiopulmonary resuscitation (CPR). These devices deliver immediate auditory, visual, or mechanical-tactile prompts to rescuers to correct chest-compression performance against resuscitation-guideline targets for compression depth, compression rate, and full chest recoil, and to minimise pauses in compressions.

Three categories of real-time feedback devices were included:

1. Defibrillator-integrated audiovisual systems: Built-in modules within defibrillators (e.g. ZOLL Real CPR Help®, Philips Q-CPR, corpuls³), providing on-screen numerical/graphical read-outs together with audio alerts for compression metrics.
2. Standalone mechanical-tactile handheld devices: Independent physical devices placed between rescuer hands and the patient's chest (e.g. Cardio First Angel), generating tactile resistance and audible clicks when target compression force and depth are achieved.
3. Audio-only prompt devices: Metronomes and timing tools delivering purely auditory cues to guide compression rate and limit compression interruptions, without visual or mechanical-tactile feedback.

Only feedback delivered during ongoing CPR qualified for the intervention. Post-event debriefing or retrospective feedback after resuscitation ended was not considered eligible for this review. Mechanical CPR devices lacking real-time feedback functionality were also excluded.

**Comparator** The comparator group received standard conventional cardiopulmonary resuscitation (CPR) without real-time chest-compression feedback.

Eligible control conditions included:

1. Standard manual CPR with the feedback function of defibrillators intentionally disabled;
2. Conventional CPR performed without any real-time feedback device;

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3. Resuscitation delivered without audiovisual, mechanical-tactile or metronome-based real-time prompts for chest-compression performance.

Rescuers in comparator groups followed routine clinical resuscitation practice according to local guidelines. Post-event review or debriefing after CPR was permitted in the control arm, as long as no real-time feedback was provided during the cardiac-arrest event itself. Studies without a non-feedback control group were excluded from this review.

**Study designs to be included** This review included comparative study designs evaluating the clinical effects of real-time chest compression feedback devices versus standard CPR. Eligible study types were as follows:
1. Randomised controlled trials (RCTs), including individual-level RCTs and cluster-randomised trials.
2. Prospective cohort studies and retrospective cohort studies.
3. Before-after studies.
4. Prospective interventional comparative studies.

No language restrictions were imposed for study inclusion.

Study designs that were excluded: case reports, case series.

**Eligibility criteria** Beyond the PICOS-related criteria described above, the following additional inclusion and exclusion criteria were applied:

Additional inclusion criteria

1. Publication timeframe: studies available from database inception up to 1 February 2026.
2. Language: no language restrictions were applied for published articles.
3. Reporting: studies must report at least one pre-specified clinical outcome (return of spontaneous circulation, survival to hospital discharge, 7-day survival or 30-day survival).
4. Full-text comparative study publications; raw or extractable event-count data for intervention and control groups had to be obtainable for quantitative meta-analysis.

Additional exclusion criteria

1. Non-comparative single-arm studies without a suitable control group receiving standard CPR.
2. Simulation/manikin-only studies, animal experimental studies with no human patient outcome data.
3. Publication types: case reports, case series, reviews, editorials, commentaries, conference abstracts, letters.
4. Duplicate reports based on the identical patient cohort: only the most comprehensive or most recent publication was retained; redundant duplicates were excluded.
5. Studies investigating only post-resuscitation debriefing / retrospective feedback, without real-time feedback delivered during ongoing CPR.
6. Studies assessing mechanical CPR devices that have no real-time chest-compression feedback functionality.
7. Studies where paediatric and adult data were mixed and adult-specific outcome numbers could not be separated.

**Information sources** Electronic databases: Five bibliographic databases were searched from database inception to 1 February 2026: PubMed, Web of Science, Cochrane Library, Embase and Scopus. Complete database-specific search strategies are documented in supplementary material.

Correspondence with study authors: Corresponding authors of eligible studies were contacted by email to request missing event counts or clarify ambiguous methodological details (e.g. definitions of ROSC or survival time-points). Where authors did not reply or requested data remained unavailable, missing data were handled by multiple imputation or the study was excluded from relevant analyses as appropriate.

Trial registers: This review was prospectively registered on PROSPERO (International Prospective Register of Systematic Reviews); however, no dedicated trial-register searching was performed to identify additional unpublished studies.

Grey-literature searching: Formal targeted grey-literature searches were not undertaken; conference abstracts were excluded per eligibility criteria.

Reference lists of included papers and relevant published meta-analyses were manually screened to identify any potentially missed eligible studies.

**Main outcome(s)** Primary outcome: Return of spontaneous circulation (ROSC), recorded intra-arrest during resuscitation. ROSC is an immediate physiological surrogate endpoint reflecting successful initial resuscitation.

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Secondary outcomes: Short-to-medium-term survival endpoints: survival to hospital discharge, 7-day survival, and 30-day survival. These are patient-centred clinical outcomes. For pooled analysis, the three survival time-points were combined into a composite survival endpoint to improve statistical power; subgroup analysis by survival time-point was also performed. Favourable neurological survival (e.g. CPC 1-2) was intended as a desirable outcome but could not be quantitatively synthesised due to inconsistent reporting, varying assessment tools and follow-up intervals across studies.

Effect measure: Odds ratio (OR) with corresponding 95% confidence intervals (95% CI) for dichotomous outcomes.

**Quality assessment / Risk of bias analysis** Two independent reviewers appraised risk of bias, with disagreements resolved via discussion or consultation with a third senior reviewer.

For randomised controlled trials and cluster-randomised trials, the Cochrane Risk of Bias 2 (RoB 2) tool was applied. For non-randomised interventional studies, the ROBINS-I (Risk Of Bias In Non-randomised Studies-of-Interventions) tool was used. Each study was assigned an overall risk-of-bias judgement: low, some concerns/ moderate, or high/serious risk.

The GRADE (Grading of Recommendations Assessment, Development and Evaluation) framework was used to rate the certainty of evidence for the primary outcome (ROSC) and key secondary survival outcomes (survival to hospital discharge, 30-day survival). GRADE judgements considered risk of bias, inconsistency, imprecision, publication bias and indirectness.

Risk-of-bias summary figures were generated to visualise assessments across study domains and individual studies.

**Strategy of data synthesis** Analyses were performed using Stata 17.0 and Review Manager 5.4. For dichotomous outcomes (ROSC, survival), pooled effect sizes were calculated as odds ratios (OR) with 95% confidence intervals (CI) using the inverse-variance method. A random-effects DerSimonian-Laird model was pre-specified due to expected clinical and methodological heterogeneity across studies. A 0.5 continuity correction was applied for zero-event cells. Data from cluster-randomised trials were used as reported by original authors, who had adjusted for clustering.

Heterogeneity was assessed via Cochran's Q-test, $I^2$ statistic and $\tau^2$. $I^2$ thresholds defined low (<25 %), moderate (25-50 %), high (50-75 %) and considerable (≥75 %) heterogeneity.

Pre-specified subgroup analyses were conducted by age (<65 vs ≥65 years), device type, arrest location and survival time-point. Meta-regression tested subgroup interaction (p-for-interaction); no multiplicity adjustment was applied given the exploratory nature.

Sensitivity analyses included leave-one-out analysis, Hartung-Knapp adjustment and REML estimator to test robustness of pooled estimates.

Composite survival endpoint combined survival-to-discharge, 7-day and 30-day survival to increase statistical power, alongside separate subgroup analysis by time-point.

Publication bias was evaluated visually using funnel plots, supplemented by Begg's rank-correlation and Egger's linear-regression tests. Where data were missing, multiple imputation or exclusion from relevant analyses was used. Two-tailed $p < 0.05$ was considered statistically significant; $p < 0.10$ for heterogeneity tests.

**Subgroup analysis** Pre-specified subgroup analyses were undertaken to explore potential sources of heterogeneity and effect modification, categorised into primary and secondary subgroups.

Primary subgroups:

1. Patient age: stratified by mean/median age (<65 years versus ≥65 years). The 65-year cut-off was selected as a geriatric threshold reflecting differences in comorbidity burden and chest-wall compliance.
2. Feedback device type: defibrillator-integrated audiovisual systems, standalone mechanical-tactile devices, and audio-only prompt devices, corresponding to different feedback mechanisms.

Secondary subgroups:

1. Cardiac-arrest location: out-of-hospital cardiac arrest (OHCA) versus in-hospital cardiac arrest (IHCA), reflecting differences in working environment and rescuer characteristics.
2. Survival time-point: survival to hospital discharge, 7-day survival, and 30-day survival, to distinguish short-term versus medium-term clinical benefits.

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Meta-regression was used to calculate p-values for subgroup interaction instead of relying on visual overlap of confidence intervals. Owing to the exploratory nature of multiple subgroup comparisons, no statistical adjustment for multiplicity was performed. Subgroup findings were regarded as hypothesis-generating rather than definitive conclusions.

**Sensitivity analysis** Multiple pre-specified sensitivity analyses were performed to test the robustness of pooled effect estimates for primary (ROSC) and composite secondary (survival) outcomes.

First, leave-one-out analysis was conducted, iteratively removing one individual study at a time and recalculating the pooled effect size. This assessed whether any single study disproportionately drove the overall meta-analytic result.

Second, alternative random-effects estimators were applied to evaluate model dependency: the Hartung-Knapp (HK) adjustment and the restricted maximum-likelihood (REML) estimator. These methods test whether conclusions remain consistent when departing from the primary DerSimonian-Laird random-effects model.

For studies with zero events in intervention or control arm, a continuity correction of 0.5 was applied in the main analysis. Missing data were handled either via multiple imputation or by excluding the study from that specific analysis.

Results from all sensitivity runs were interpreted together. Where effect directions and statistical significance remained stable, the main pooled result was considered robust. Any material change in magnitude or significance triggered cautious interpretation of the main finding. All sensitivity outputs were presented in supplementary figures. No sensitivity analysis based on study design was performed due to insufficient number of studies within each design stratum.

**Country(ies) involved** China.

**Keywords** Heart arrest; cardiopulmonary resuscitation; emergency medical services; feedback; Meta-Analysis.

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