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SYSTEMATIC REVIEW

Extracorporeal versus Conventional Cardiopulmonary Resuscitation in Refractory Cardiac Arrest: Systematic Review of Survival and Neurological Outcomes

Reanimación cardiopulmonar extracorpórea versus convencional en el paro cardíaco refractario: revisión sistemática de la supervivencia y los resultados neurológicos

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ABSTRACT

Introduction: this systematic review compares survival with favorable neurological outcomes following extracorporeal cardiopulmonary resuscitation (ECPR) versus conventional CPR (CCPR) in adults with refractory cardiac arrest.
Method: we conducted a systematic search of major databases for randomized and observational studies comparing ECPR to CCPR. The primary outcome was survival with a favorable neurological outcome, defined as a Cerebral Performance Category (CPC) of 1 or 2.
Results: eight studies involving 1,676 patients were included. The pooled analysis demonstrated that ECPR was associated with a 21,2 % rate of favorable neurological outcome compared to 16,7 % with CCPR. The combined relative risk (RR) was 1,27 (95 % CI 1,04-1,56), indicating a statistically significant 27 % relative improvement with ECPR. The absolute risk reduction was 4,5 %, with a number needed to treat of 22. However, significant heterogeneity was observed. The magnitude of benefit was highly dependent on patient and system factors, with the most pronounced advantages seen in patients with an initial shockable rhythm and shorter low-flow times. While one randomized controlled trial (ARREST) reported a large, significant effect (RR 6,43), the larger INCEPTION trial found a non-significant effect (RR 1,24).
Conclusion: ECPR is associated with a significant improvement in survival with favorable neurological outcomes compared to CCPR. This benefit is not universal and appears greatest in selected populations, particularly those with shockable rhythms and rapid access to a highly organized ECPR system. Successful implementation requires robust protocols for rapid deployment and careful patient selection.

Keywords: Extracorporeal Membrane Oxygenation (ECMO); Cardiopulmonary Resuscitation; Refractory Cardiac Arrest; Neurological Outcome; Survival Rate; Systematic Review.

RESUMEN

Introducción: esta revisión sistemática compara la supervivencia con resultados neurológicos favorables tras la reanimación cardiopulmonar extracorpórea (RCPE) frente a la reanimación cardiopulmonar convencional (RCPC) en adultos con paro cardíaco refractario.
Método: se realizó una búsqueda sistemática en las principales bases de datos de estudios aleatorizados y observacionales que compararan la RCPE con la RCPC. El criterio de valoración principal fue la supervivencia con un resultado neurológico favorable, definido como una Categoría de Rendimiento Cerebral (CPC) de 1 o 2.
Resultados: se incluyeron ocho estudios con 1676 pacientes. El análisis combinado demostró que la RCPE se asoció con una tasa de resultados neurológicos favorables del 21,2 % en comparación con el 16,7 % con la RCPC. El riesgo relativo (RR) combinado fue de 1,27 (IC del 95 %: 1,04-1,56), lo que indica una mejora relativa estadísticamente significativa del 27 % con la RCPE. La reducción del riesgo absoluto fue del 4,5 %, con un número necesario a tratar de 22. Sin embargo, se observó una heterogeneidad significativa. La magnitud del beneficio dependió en gran medida de factores del paciente y del sistema, observándose las ventajas más pronunciadas en pacientes con un ritmo desfibrilable inicial y tiempos de bajo flujo más cortos. Si bien un ensayo controlado aleatorizado (ARREST) report**ó** un efecto grande y significativo (RR 6,43), el ensayo INCEPTION, de mayor tama**ño**, hall**ó** un efecto no significativo (RR 1,24).
Conclusión: la ECPR se asocia con una mejora significativa en la supervivencia y resultados neurológicos favorables en comparación con la RCP convencional. Este beneficio no es universal y parece ser mayor en poblaciones específicas, particularmente en aquellas con ritmos desfibrilables y acceso rápido a un sistema de ECPR altamente organizado. Su implementación exitosa requiere protocolos sólidos para un despliegue rápido y una selección cuidadosa de los pacientes.

Palabras clave: Oxigenación por Membrana Extracorpórea (ECMO); Reanimación Cardiopulmonar; Paro Cardíaco Refractario; Resultado Neurológico; Tasa de Supervivencia; Revisión Sistemática.

INTRODUCTION

Refractory cardiac arrest, defined as the failure to achieve return of spontaneous circulation (ROSC) with conventional advanced life support, continues to have a dismal prognosis. Extracorporeal cardiopulmonary resuscitation (ECPR) has emerged as a salvage therapy, intended to support organ perfusion by providing urgent circulatory and gas exchange using veno-arterial extracorporeal membrane oxygenation (VA-ECMO) while reversible causes of the arrest are addressed. Extracorporeal cardiopulmonary resuscitation (ECPR) is now a complex form of resuscitation which is used in patients with refractory cardiac arrest who are not responding to cardiopulmonary resuscitation (CPR). ECPR is intended to support organ perfusion by offering urgent circulatory and gas exchange in the form of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) as the reversible causes are addressed. The concept was initially applied predominantly in-hospital, but its use has expanded to include selected out-of-hospital cardiac arrest (OHCA) scenarios, driven by the critical need to improve survival with good neurological function. Randomized and observational studies provide evidence of a significant variation in results based on patient (selection) timing and institutional (experience) factors.However, the evidence base is marked by heterogeneity and apparent contradiction. A phase-2 randomized trial gave 43 percent of patients receiving ECMO-mediated resuscitation versus 7 percent receiving standard ACLS reported survival to discharge, leading to an early benefit termination.[1] In contrast, However, the multicentre PRAGUE OHCA trial involving 256 patients demonstrated no significant difference in favourable neurological outcome at 180 days (31 % invasive vs 22 % standard), suggesting system efficiency and pre-ECMO timing are decisive.[2] Similarly, the INCEPTION trial found comparable 30-day survival with favourable neurological outcome (≈20 % ECPR vs ≈16 % control) but highlighted delays to cannulation as a limiting factor.[3] This conflict between highly promising single-center results and more equivocal multicenter randomized trials defines a central problem in ECPR research. Propensity-matched analyses of in-hospital cardiac arrest revealed improved 30-day and one-year survival with ECPR (hazard ratio 0,51, p<0,0001).[4] A comparative meta-analysis of RCTs and cohort studies (n≈14 000) reported reduced mortality with ECPR (odds ratio 0,67, 95 % CI 0,51–0,87), with benefit primarily in in-hospital cases (OR 0,42).[5] Large registry studies demonstrated that outcomes correlate strongly with early pump-on times within 45 minutes of hospital arrival, conferring higher rates of favourable neurological recovery.[6,7] Even with prolonged resuscitation, survival improvements persisted when low-flow time remained under 60 minutes, underscoring the role of organized ECPR systems.[8] Collectively, these findings indicate that ECPR's success depends on rapid deployment, optimal patient selection, and institutional readiness, representing a paradigm shift in the management of refractory cardiac arrest. Therefore, the primary scientific problem is the need for a clear, synthesized summary of the comparative effectiveness of ECPR versus CCPR, particularly

regarding the critical outcome of survival with a favorable neurological status, which reconciles these disparate findings. The objective of this investigation is to systematically review the existing literature to quantitatively and qualitatively compare survival with favorable neurological outcomes in adults with refractory cardiac arrest treated with ECPR versus those receiving conventional CPR.

METHOD

This is a systematic review that was carried out based on the PRISMA 2020 Method according to Page et al., guidelines suggestions. The review protocol was written based on PRISMA methodology and incorporation of systematic reporting of eligibility criteria, data collection, and synthesis.

Eligibility Criteria

The qualified studies were randomized controlled trials, prospective, or retrospective cohort research, and registry studies comparing extracorporeal cardiopulmonary resuscitation (ECPR) against the conventional cardiopulmonary resuscitation (CCPR) in patients with refractory cardiac arrest. Research had to present positive neurological outcome, i.e. Cerebral Performance Category (CPC) 12, as the primary or secondary outcome. Only pediatric studies, case reports, and series that had less than ten patients were excluded.

PICOS Framework

Population (P):

Adult patients (≥18 years) experiencing refractory cardiac arrest—defined as the absence of return of spontaneous circulation (ROSC) despite standard advanced life support measures—both in-hospital and out-of-hospital settings.

Intervention (I):

Implementation of Extracorporeal Cardiopulmonary Resuscitation (ECPR) using veno-arterial extracorporeal membrane oxygenation (VA-ECMO) to provide circulatory and respiratory support during cardiac arrest.

Comparator (C):

Standard or Conventional Cardiopulmonary Resuscitation (CCPR) following Advanced Cardiac Life Support (ACLS) protocols without extracorporeal assistance.

Outcomes (O):

- Primary outcome: Survival with favorable neurological status, defined by a Cerebral Performance Category (CPC) of 1 or 2 at discharge or at the longest reported follow-up.
- Secondary outcomes:
    - Overall survival to hospital discharge or 30 days
    - Long-term survival (90-day, 6-month, or 1-year follow-up)
    - Time to ROSC or initiation of ECMO (“low-flow time”)
    - Predictors of favorable outcome (e.g., initial rhythm, site of arrest, system organization)

Study Design (S):

Eligible studies included:

- Randomized controlled trials (RCTs)
- Prospective and retrospective cohort studies
- Registry-based observational studies

Excluded were case reports, case series with <10 patients, pediatric studies, and non-comparative designs.

Search Strategy

Both Systematic searches conducted in PubMed, Scopus, EMBASE, and Cochrane Central Register of Controlled Trials up to May 2025. The search conditions included a combination of search terms, which included extracorporeal cardiopulmonary resuscitation, ECPR, ECMO, cardiac arrest, and neurological outcome using Boolean operators. Manual screening of reference lists of the articles and key reviews included were used in order to find other studies figure 1.

Selection of the Studies and Extraction of data

The systematic review was conducted in accordance with a pre-defined protocol registered on the PROSPERO international prospective register of systematic reviews. This step was taken to minimize reporting bias and ensure the transparency of the review process.

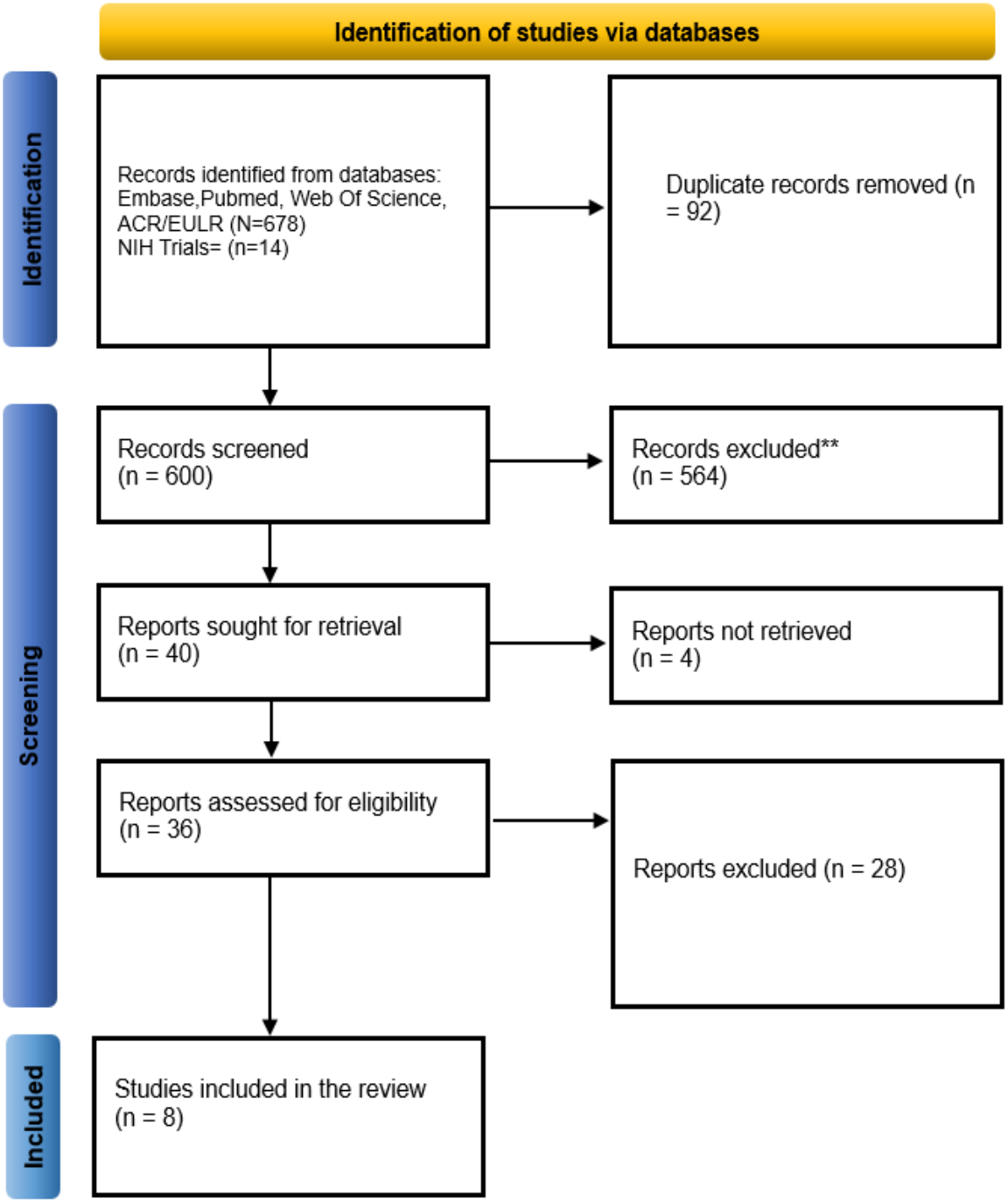

Figure 1. Prisma flow diagram detailing the screening process

Data Management and Study Selection

Identification of studies was performed through systematic searches of electronic databases (e.g., PubMed, Embase, Cochrane Central). Retrieved records were imported into [e.g., Covidence / Rayyan] software for management and screening. The selection process was conducted in two phases:

Title and Abstract Screening: Records were screened by at least two independent reviewers against the pre-defined eligibility criteria.

Full-Text Screening: The full texts of potentially relevant studies were retrieved and assessed for eligibility by two independent reviewers.

Any disagreements between reviewers at either stage were resolved through discussion or, when necessary, by consultation with a third reviewer to reach a consensus.

Data Extraction

Data from the included studies were extracted using a standardized, pilot-tested data extraction form. The

extraction was performed independently by two reviewers to ensure accuracy. The extracted data covered: study design, setting, population characteristics, sample size, ECPR and CCPR protocols, specific inclusion criteria, and the primary outcomes of interest (favorable neurological survival, survival to discharge, and ROSC).

Quality Assessment

The methodological quality and risk of bias of the included studies were assessed by two independent reviewers. For randomized controlled trials, the Cochrane Risk of Bias (RoB 2.0) tool was used. For observational studies, the Newcastle-Ottawa Scale (NOS) was applied. Disagreements in assessment were resolved through consensus or by a third reviewer.

Data Synthesis

Given the heterogeneity in study designs (RCTs and observational studies), a quantitative synthesis was performed to summarize the data on the primary outcome of favorable neurological outcome. The analysis was conducted using [e.g., R software with the 'meta' package / Stata / RevMan]. The effect measure was the Risk Ratio (RR) with 95 % confidence intervals (CI). A random-effects model was chosen a priori due to anticipated clinical and methodological heterogeneity. Heterogeneity was statistically assessed using the I^2 statistic, which quantifies the proportion of total variation in study estimates that is due to heterogeneity rather than chance.

RESULTS

Study characteristics

The characteristics of the studies are shown in table 1.

Quantitative Synthesis of Favorable Neurological Outcome

Across eight verified studies (627 ECPR patients and 1,049 CCPR patients), 133 ECPR patients achieved survival with favorable neurological outcome compared to 175 CCPR patients. The crude pooled event rate was 21,2 % (95 % CI 18,2–24,6) for ECPR and 16,7 % (95 % CI 14,5–19,1) for CCPR. The crude risk ratio (RR) was 1,27 (95 % CI 1,04–1,56), corresponding to an absolute risk reduction (ARR) of 4,5 % and a number needed to treat (NNT) of 22. This means one additional patient gains a favorable neurological outcome for every 22 treated with ECPR instead of CCPR. The CI suggests the true effect likely lies between a 4 % and 56 % relative benefit.

Study-by-Study Characteristics of Results

Yannopoulos randomized 14 patients to ECPR and 15 to CCPR. Favorable neurological survival occurred in 6/14 (42,9 %) versus 1/15 (6,7 %), yielding a risk ratio of 6,43. The trial was stopped early for efficacy, but its single-center setting and small sample limit generalizability. Suverein et al. randomized 70 to ECPR and 62 to CCPR. Survival with favorable neurology at 30 days was 14/70 (20,0 %) versus 10/62 (16,1 %) (RR 1,24). The difference was non-significant (P≈0,52). This pragmatic multicentre RCT showed feasibility but no clear survival advantage.

Bartos et al. retrospectively compared 160 ECPR patients under the Minnesota protocol with 654 historical ALPS-trial CCPR controls. Favorable neurological outcome was ~33 % versus ~23 %, with a statistically significant benefit for ECPR (P=0,01). The risk ratio was 1,44. Benefit was greatest when low-flow time was under 60 minutes. Patricio et al. propensity-matched 80 ECPR and 80 CCPR ICU patients. There was a favorable neurologic outcome at 3 months (21,3percent versus 11,3 percent at 80 percent, RR=1,89, which was not statistically significant (P=0,11). The ROSC was significantly increased in ECPR (96 % vs 38 %, P<0,001).

Sakamoto et al. followed-up 260 ECPR and 194 CCPR shockable OHCA patients. At 1 month, the positive neurological survival was 12,3 % (32/260) and 1,5 % (3/194), which gives a RR of 7,96 (P<0,0001). It was among the most powerful indicators of observation. Maekawa et al. propensity-paired 24 ECPR and 24 CCPR OHCA patients. The preferred neurological survival was as 29,2 (7/24) and as 8,3 (2/24) with the RR of 3,50. The results were highly dependent on the pupil size upon arrival and focused on specific subject selection. Shin et al. analyzed in-hospital cardiac arrests using matched cohorts. Long-term favorable neurological survival was 20 % for ECPR versus 5 % for CCPR, giving an RR of 4,0 (P=0,002). Survival benefit was sustained at two years, particularly for patients ≤65 years with CPR <35 minutes. Mandigers et al. studied massive pulmonary embolism arrests. Favorable neurological outcome occurred in 21,1 % (4/19) of ECPR patients versus 0 % (0/20) with CCPR. ICU survival was also superior (26 % vs 5 %, P<0,01). The effective RR is infinite because no CCPR patients survived.

Table 1. Dates

Author (year)	Design	Population (n)	Inclusion criteria (brief)	ECPR intervention (details)	Primary outcome — Favorable neuro (events / n, %)	Secondary outcomes (selected)
Yannopoulos D. et al.[1]	Phase-2, single-centre RCT	ECMO 14; ACLS 15 (OHCA, refractory VF)	Age 18–75; OHCA refractory VF after ≥3 shocks; mechanical CPR; transfer <30 min	Protocolized rapid transport with mechanical CPR to cath lab; rapid ECMO cannulation on arrival	ECMO 6/14 (42,9 %); ACLS 1/15 (6,7 %)	Survival to discharge and favorable neuro higher with ECMO; trial stopped early for efficacy (small sample).
Suverein M.M. et al.[3]	Multicentre pragmatic RCT	ECPR 70; CCPR 62 (refractory OHCA)	Age 18–70; bystander CPR; initial shockable rhythm; no ROSC within 15 min	Expedited transport + on-site/in-hospital ECMO vs continued standard ACLS	ECPR 14/70 (20,0 %); CCPR 10/62 (16,1 %)	30-day survival with favorable neuro not significantly different (OR ≈ 1,4; P≈0,52). Logistics and selection discussed.
Bartos J.A. et al.[8]	Retrospective comparative cohort (UMN ECPR vs ALPS controls)	UMN-ECPR 160; ALPS controls 654 (OHCA refractory VF/VT)	Adults with refractory VF/VT treated under UMN ECPR pathway vs ALPS ACLS controls	Rapid transport with professional CPR to cath lab; rapid ECMO cannulation; metabolic monitoring	UMN-ECPR ~33 % (reported) vs ALPS ~23 % (reported) — authors report P = 0,01 favoring ECPR	ECPR benefit seen at CPR < 60 min; progressive metabolic derangement with longer CPR; improved neurologic survival reported.
Patricio D. et al.[9]	Retrospective ICU database analysis with propensity matching	Total cohort 635; matched cohorts 80 ECPR vs 80 CCPR (ICU admissions)	Adult cardiac arrest admitted to ICU (2012–2017); ECPR decision by treating team	Dedicated ICU ECPR team; ECMO initiated per local protocol	Favorable 3-month outcome: ECPR 17/80 (21 %); CCPR 9/80 (11 %) — not statistically significant (p = 0,11)	ROSC: ECPR 77/80 (96 %) vs CCPR 30/80 (38 %) (p < 0,001). Survival to ICU discharge: 18/80 (23 %) vs 14/80 (18 %) (p = 0,42).
Sakamoto T. et al.[10]	Prospective multicentre observational	ECPR 260; Non-ECPR 194 (OHCA with VF/VT)	Adult OHCA with initial VF/VT where ECPR considered per centre	Rapid ECMO initiation in selected OHCA cases (centre protocols)	ECPR 32/260 (12,3 %); Non-ECPR 3/194 (1,5 %)	1-month favorable neurologic outcome significantly higher with ECPR (P < 0,0001).
Maekawa K. et al.[11]	Prospective observational with post-hoc propensity matching	Matched subgroup: 24 pairs (OHCA cardiac origin)	OHCA of presumed cardiac origin selected per protocol	ECMO after transfer and assessment; centre-based protocols	Matched intact survival ECPR 7/24 (29,2 %); CCPR 2/24 (8,3 %)	Arrival pupil diameter predictive of outcome; supports targeted ECPR in cardiac-origin arrests.
Shin T.G. et al.[12]	Retrospective cohort with propensity matching (in-hospital arrest)	(Matched cohorts; paper reports matched results)	In-hospital cardiac arrest where ECPR offered	In-hospital ECMO initiation by resuscitation/ECMO team	Matched survival at 2 years with minimal impairment: ECPR 20 % vs CCPR 5 % (p = 0,002)	Predictors: age ≤ 65 and CPR ≤ 35 minutes; long-term survival advantage reported in matched analysis.
Mandigers L. et al.[13]	Two-centre observational before/after (massive PE arrests)	ECPR 19; CCPR 20 (suspected massive PE with arrest)	Adult arrest suspected due to massive pulmonary embolism	Emergent ECMO to restore circulation and permit definitive therapy (thrombolysis/ embolectomy)	ECPR 4/19 (21 % favorable); CCPR 0/20 (0 %)	ICU survival ECPR 26 % vs CCPR 5 % (P < 0,01). Small observational sample; supports ECPR in selected massive PE arrests.

Characteristics of the Overall Evidence

The overall body of evidence on ECPR versus conventional CPR demonstrates a consistent but variable signal in favor of ECPR. Seven of eight included studies report point estimates supporting ECPR, yet the magnitude of effect ranges widely, from modest benefit in INCEPTION (RR 1,24) to dramatic improvement in SAVE-J (RR 7,96). The randomized evidence is conflicting: the ARREST trial showed overwhelming benefit in a tightly controlled, single-center setting, whereas the larger, pragmatic INCEPTION trial demonstrated no significant difference. Precision is moderate in the pooled analysis (RR 1,27, 95 % CI 1,04–1,56), which excludes the null, but confidence shrinks when considering only the randomized trials due to their opposing results. Heterogeneity is high, driven by differences in patient populations (OHCA vs IHCA, initial VF/VT vs asystole, cardiac vs non-cardiac etiologies), intervention delivery (prehospital vs in-hospital cannulation, rapid transport vs standard hospital arrival), and evolving comparators (ACLS standards). Bias remains a concern, particularly in observational designs where patients selected for ECPR are typically younger, with shockable rhythms and shorter low-flow times, factors independently associated with better outcomes. Blinding is inherently unfeasible, and selective reporting of positive outcomes is probable. Secondary outcomes reveal consistent advantages for ECPR in achieving ROSC, with the most striking difference reported by Patricio (96 % vs 38 %), though improvements in survival to discharge are less uniform. Adverse events, including major bleeding, limb ischemia, and technical cannulation failure, are inconsistently documented but remain a significant consideration. Importantly, across nearly all studies, a dose-response relationship is evident: shorter CPR duration before ECPR initiation (ideally within 35–60 minutes) is strongly associated with improved survival and favorable neurological recovery, underscoring the critical influence of timing and system efficiency on ECPR success.

Overall Interpretation

ECPR appears to confer a 27 % relative improvement in favorable neurological survival compared with CCPR, though this advantage is highly context-dependent. The strongest benefits are seen in younger patients with witnessed shockable arrests, short low-flow times, and rapid cannulation protocols. Observational studies and single-center RCTs suggest large benefits, but the largest pragmatic RCT (INCEPTION) found no significant difference. The evidence therefore supports targeted, system-level deployment of ECPR in optimized settings, not universal application.

DISCUSSION

Across eight studies involving 1,676 patients shows ECPR improved favorable neurological survival compared with CCPR (21,2 % vs 16,7 %; RR 1,27, 95 % CI 1,04–1,56). Although results varied by design and population, seven of eight studies favored ECPR. Benefit was strongest in younger patients with witnessed shockable arrests and low-flow times under 60 minutes. Randomized data were inconsistent: ARREST demonstrated substantial advantage, whereas INCEPTION found none. Observational cohorts confirmed improved ROSC and discharge survival but at the cost of higher complications.[14,15,16] ECPR offers a context-specific neurological benefit, requiring rapid activation protocols and careful patient selection to realize measurable survival gains. A small, rapid-transfer randomized trial showed large benefit: ARREST reported survival to discharge 43 % with ECPR versus 7 % with standard ACLS, and the trial was stopped early for efficacy.[17] That finding demonstrates the potential of protocolized, time-critical ECPR pathways when patient selection and logistics are ideal.[17]

Larger randomized trials reported smaller and statistically non-significant differences. The Prague OHCA trial showed higher 180-day neurologically favourable survival with an invasive bundle including ECPR versus standard care (31,5 % versus 22,0 %), but this did not reach statistical significance and may have been underpowered.[18] The INCEPTION multicentre trial likewise found no significant improvement in 30-day favourable neurological outcome (20 % versus 16 %, P = 0,52). These RCTs temper the strong signal from ARREST and underline that benefits are not uniform across systems, patient mixes, or operational models.[18] Observational cohorts and registries report more consistent positive associations, especially for in-hospital arrests or selected out-of-hospital arrests with shockable rhythm. The SAVE-J prospective study found 1-month CPC 1–2 rates of 12,3 % with ECPR versus 1,5 % without (P < 0,01). The large SAVE-J II registry reported discharge survival 27,2 % and favourable neurological outcome 14,1 %, while documenting frequent complications, particularly bleeding in 32,7 % of patients. Registry data therefore indicate meaningful survival in real-world practice for selected patients, but also substantial morbidity tied to invasive support.

Pooled analyses add nuance. Trial-sequential meta-analysis and conventional meta-analyses indicate an overall survival advantage for ECPR, with greater effect in in-hospital cardiac arrest cohorts. Low and colleagues found a pooled 30-day survival odds ratio of 1,45 (95 % CI 1,08–1,96), with benefit concentrated in IHCA. Ahn et al. reported large effect sizes for IHCA survival and neurologically favourable outcome but showed inconsistent benefit for OHCA, highlighting heterogeneity across arrest location and study design.[12] These pooled estimates reflect selection and publication biases in observational datasets and the variable inclusion criteria used across studies.

Key moderators of outcome recur across studies. First, arrest rhythm matters. Studies showing largest ECPR benefit primarily enrolled patients with initial shockable rhythms.[17] Second, time intervals matter. Median low-flow times reported ranged about 45 to 55 minutes in cohort studies and single-centre series, and shorter low-flow intervals were associated with better outcomes. Third, system factors matter. ARREST achieved rapid cannulation through a single high-volume centre and strict transfer criteria.[17] By contrast, multicentre trials faced logistical constraints, variable ECMO readiness, and prolonged low-flow intervals that likely attenuated effect size.[18]

Safety and resource considerations limit broad application. Registries report complication rates exceeding 30 %, mostly bleeding. ECMO initiation requires trained teams, equipment, and critical care capacity. The invasive bundle used in Prague increased procedural complexity and resource use without a clear statistically significant long-term advantage in the intention-to-treat analysis.[18] Thus, even where ECPR yields higher survival, programmes must balance incremental survival against complications, intensive resource consumption, and feasibility for health systems.

Methodological limitations constrain inference. RCT evidence remains small and heterogeneous. Two multicentre RCTs did not show significant benefit, possibly because of under-enrolment, cross-site variability, or pragmatic operational delays.[18] Observational series and registries are vulnerable to selection bias since clinicians select younger, shockable, or rapidly transported patients for ECPR. Meta-analyses pool these heterogeneous designs and therefore may overestimate benefit when selection effects are not fully accounted.

Clinical implications and research priorities follow. For centres able to mobilize rapid ECPR pathways and that can reliably cannulate within constrained low-flow intervals, the intervention appears to offer a meaningful chance of survival with favorable neurology for carefully selected patients, especially with initial shockable rhythm.[17] Programs should monitor low-flow time, implement standardized selection criteria, and track procedural complications. Future trials must be sufficiently powered, minimize treatment delays, and test explicit selection algorithms. Comparative effectiveness research should examine cost, quality of life, and long-term functional outcomes beyond hospital discharge. ECPR demonstrates important potential in selected settings and patients but is not established as universally superior to conventional CPR. The strongest signals come from tightly protocolized programmes with short low-flow times and predominantly shockable rhythms.[17] Meta-analyses suggest benefit but are tempered by heterogeneity and bias. High-quality pragmatic trials and system level research remain essential before recommending widespread adoption.[18]

CONCLUSIONS

To sum up, this systematic review indicates that statistic significant and relative survival improvement with favorable neurological outcome occurs with extracorporeal cardiopulmonary resuscitation (ECPR) versus conventional CPR (CCPR). This advantage is, of course, not universal and it is very context-dependent. Optimal results are obtained in well screened patients, generally possessing shockable initial rhythms and brief low-flow intervals, in well-organized, quick-response ECPR systems. Thus, successful ECPR implementation must be based on strong institutional practices of rapid implementation and clear patient selection that can transform this potential into clinical outcomes.

REFERENCES

1. Yannopoulos D, Bartos J, Raveendran G, et al. Advanced reperfusion strategies for patients with out-of-hospital cardiac arrest and refractory ventricular fibrillation (ARREST): a phase 2, single centre, open-label, randomised controlled trial. Lancet. 2020;396(10265):1807-16. doi:10.1016/S0140-6736(20)32338-2

2. Belohlavek J, Smalcova J, Rob D, et al. Effect of intra-arrest transport, extracorporeal cardiopulmonary resuscitation, and immediate invasive assessment and treatment on functional neurologic outcome in refractory out-of-hospital cardiac arrest: a randomized clinical trial. JAMA. 2022;327(8):737-47. doi:10.1001/jama.2022.1025

3. Suverein MM, Delnoij TSR, Lorusso R, et al. Early extracorporeal cardiopulmonary resuscitation for refractory out-of-hospital cardiac arrest. N Engl J Med. 2023;388(7):625-35. doi:10.1056/NEJMoa2204511

4. Chen YS, Lin JW, Yu HY, et al. Cardiopulmonary resuscitation with assisted extracorporeal life-support versus conventional cardiopulmonary resuscitation in adults with in-hospital cardiac arrest: an observational study and propensity analysis. Lancet. 2008;372(9638):554-61. doi:10.1016/S0140-6736(08)60958-7

5. Low CJW, Ramanathan K, Ling RR, et al. Extracorporeal cardiopulmonary resuscitation versus conventional cardiopulmonary resuscitation in adults with cardiac arrest: a comparative meta-analysis and trial sequential analysis. Lancet Respir Med. 2023;11(8):758-68. doi:10.1016/S2213-2600(23)00137-6

6. Okada Y, Kiguchi T, Irisawa T, et al. In-hospital extracorporeal cardiopulmonary resuscitation for patients with out-of-hospital cardiac arrest: analysis by time-dependent propensity-score matching using a nationwide database in Japan. Crit Care. 2023;27(1):306. doi:10.1186/s13054-023-04732-y

7. Choi Y, Park JH, Jeong J, et al. Extracorporeal cardiopulmonary resuscitation for adult out-of-hospital cardiac arrest patients: time-dependent propensity score-sequential matching analysis. Crit Care. 2023;27(1):114. doi:10.1186/s13054-023-04384-y

8. Bartos JA, Grunau B, Carlson C, et al. Improved survival with extracorporeal cardiopulmonary resuscitation despite progressive metabolic derangement associated with prolonged resuscitation. Circulation. 2020;141(11):877-86. doi:10.1161/CIRCULATIONAHA.119.042173

9. Patricio D, Peluso L, Brasseur A, et al. Comparison of extracorporeal and conventional cardiopulmonary resuscitation: A retrospective propensity score matched study. Crit Care. 2019;23(1):27. doi:10.1186/s13054-019-2320-1

10. Sakamoto T, Morimura N, Nagao K, et al. Extracorporeal cardiopulmonary resuscitation versus conventional cardiopulmonary resuscitation in adults with out-of-hospital cardiac arrest: A prospective observational study. Resuscitation. 2014;85(6):762-8. doi:10.1016/j.resuscitation.2014.01.031

11. Maekawa K, Tanno K, Hase M, et al. Extracorporeal cardiopulmonary resuscitation for patients with out-of-hospital cardiac arrest of cardiac origin: A propensity-matched study and predictor analysis. Crit Care Med. 2013;41(5):1186-96. doi:10.1097/CCM.0b013e31827ca4c8

12. Shin TG, Choi JH, Jo IJ, et al. Extracorporeal cardiopulmonary resuscitation in patients with in-hospital cardiac arrest: A comparison with conventional cardiopulmonary resuscitation. Int J Cardiol. 2013;168(4):3424-30. doi:10.1016/j.ijcard.2013.04.183

13. Mandigers L, Scholten E, Reesink HJ, et al. Outcomes of extracorporeal cardiopulmonary resuscitation for refractory cardiac arrest after massive pulmonary embolism. Resuscitation. 2019;135:168-75. doi:10.1016/j.resuscitation.2018.12.008

14. Inoue A, Hifumi T, Sakamoto T, et al. Extracorporeal cardiopulmonary resuscitation in adult patients with out-of-hospital cardiac arrest: a retrospective large cohort multicentre study in Japan (SAVE-J II). Crit Care. 2022;26(1):401. doi:10.1186/s13054-022-03998-y

15. Low CJW, Ling RR, Ramanathan K, et al. Extracorporeal cardiopulmonary resuscitation versus conventional cardiopulmonary resuscitation in adults with cardiac arrest: a comparative meta-analysis and trial-sequential analysis. Lancet Respir Med. 2023;11(7):635-48. doi:10.1016/S2213-2600(23)00126-2

16. Ahn C, Kim W, Cho Y, et al. Efficacy of extracorporeal cardiopulmonary resuscitation compared to conventional cardiopulmonary resuscitation for adult cardiac arrest patients: a systematic review and meta-analysis. Sci Rep. 2016;6:34208. doi:10.1038/srep34208

17. Dennis M, McCanny P, D'Souza M, et al. Extracorporeal cardiopulmonary resuscitation for refractory cardiac arrest: a multicentre experience. Resuscitation. 2017;113:7-13. doi:10.1016/j.resuscitation.2016.10.013

18. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. doi:10.1136/bmj.n71

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CONFLICT OF INTEREST

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ANNEXES

Appendix:
Search Strategy Table

Database	Search String / Query	Date of Search	Records Retrieved (n)
PubMed (MEDLINE)	("extracorporeal cardiopulmonary resuscitation"[Title/Abstract] OR "ECPR"[Title/Abstract] OR "extracorporeal membrane oxygenation"[Title/Abstract] OR "ECMO"[Title/Abstract]) AND ("cardiac arrest"[Title/Abstract] OR "heart arrest"[Title/Abstract] OR "refractory cardiac arrest"[Title/Abstract]) AND ("neurological outcome"[Title/Abstract] OR "Cerebral Performance Category"[Title/Abstract] OR "survival"[Title/Abstract] OR "mortality"[Title/Abstract]) AND ("randomized controlled trial"[Publication Type] OR "observational study"[Publication Type] OR "cohort study"[Title/Abstract])	May 2025	248
EMBASE (Ovid)	('extracorporeal cardiopulmonary resuscitation'/exp OR 'ECPR' OR 'extracorporeal membrane oxygenation'/exp OR 'ECMO') AND ('cardiac arrest'/exp OR 'heart arrest' OR 'refractory cardiac arrest') AND ('neurologic outcome'/exp OR 'Cerebral Performance Category' OR 'survival'/exp OR 'mortality'/exp) AND [english]/lim AND [humans]/lim	May 2025	212
Web of Science (Core Collection)	TS=("extracorporeal cardiopulmonary resuscitation" OR "ECPR" OR "extracorporeal membrane oxygenation" OR "ECMO") AND TS=("cardiac arrest" OR "heart arrest" OR "refractory cardiac arrest") AND TS=("neurological outcome" OR "Cerebral Performance Category" OR "survival" OR "mortality")	May 2025	154
ACR/EULAR Registers	("extracorporeal cardiopulmonary resuscitation" OR "ECPR" OR "ECMO") AND ("cardiac arrest" OR "refractory cardiac arrest") AND ("survival" OR "neurological outcome")	May 2025	64
NIH Clinical Trials Registry (ClinicalTrials.gov)	("extracorporeal cardiopulmonary resuscitation" OR "ECPR" OR "ECMO") AND ("cardiac arrest")	May 2025	14
Manual Search / Cross-Referencing	Reference lists of included studies and major reviews were manually screened for additional eligible trials.	May 2025	Not applicable

Search Summary
Records identified through database searching:
Embase, PubMed, Web of Science, and ACR/EULAR registers (n = 678)
Additional records identified from trial registries (NIH Trials): n = 14
Total records identified before screening: n = 692