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Meta-Analysis

Timing of resuscitative hysterotomy and maternal outcomes after cardiac arrest: a systematic review and meta-analysis

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ABSTRACT

Resuscitative hysterotomy (RH) is undertaken during maternal cardiac arrest to relieve aortocaval compression and improve maternal resuscitation. The optimal timing and magnitude of maternal benefit remain uncertain because evidence is observational. The search strategy included Pubmed, Scopus and Embase database evidence. Eligible primary studies reported maternal or neonatal outcomes according to time from arrest to RH. Random-effects synthesis was used in the base analysis. The primary outcome was maternal survival in relation to arrest-to-hysterotomy time; secondary outcomes included neonatal survival, maternal survival to discharge, neurological outcome and ROSC. An exploratory random-effects logit meta-analysis of survival proportions was undertaken across three major evidence syntheses, but was not used for causal inference because of overlap. The base search identified 762 records; 12 studies (507 patients) were included and 8 studies (176 patients, including 111 undergoing RH) contributed to quantitative synthesis. Maternal survivors underwent hysterotomy at a pooled mean time of 12.55±4.85 minutes, significantly earlier than non-survivors (p=0.023; I^2=71%). Neonatal survival was associated with a pooled mean time of 10.25±5.50 minutes (p=0.034; I^2=85%). The exploratory review-level analysis yielded a pooled maternal survival proportion of 19.8% (95% CI 3.8-60.4%; I^2=94.3%), but this estimate is highly vulnerable to overlap and case-mix differences. A 2026 tertiary-centre cohort reported two hysterotomies completed at four minutes with 100% neonatal survival; maternal RH-specific survival was not separately reported. Earlier RH is associated with better maternal and neonatal survival, but the evidence is very low certainty, heterogeneous and confounded. The five-minute target remains an operational goal rather than an absolute futility threshold. Prospective registries with patient-level timing and neurological outcomes are required.

Keywords: Maternal cardiac arrest, Resuscitative hysterotomy, Perimortem caesarean delivery, Maternal survival, Timing, Meta-analysis, Return of spontaneous circulation

INTRODUCTION

Maternal cardiac arrest is rare but demands simultaneous high-quality cardiopulmonary resuscitation, pregnancy-specific modifications and immediate treatment of reversible causes. In later pregnancy, aortocaval compression by the gravid uterus can markedly reduce venous return and effectiveness of chest compressions.[1-3]

RH, historically termed perimortem caesarean delivery, is performed primarily to improve maternal resuscitation.

Uterine evacuation relieves aortocaval compression, improves venous return, improves diaphragmatic excursion, reduces oxygen consumption and metabolic demand and returns uteroplacental blood to the maternal circulation.[1,4,5]

The traditional recommendation to begin the procedure by four minutes and achieve delivery by five minutes was derived from physiological reasoning and selected case reports rather than randomised evidence. Contemporary guidance therefore treats five minutes as an operational target and recommends preparation immediately when arrest is recognised and the uterine fundus is at or above the umbilicus.[2,3,6]

The evidence base has expanded from case reports to national surveillance studies, prehospital series and meta-analysis. The 2026 systematic review and meta-analysis identified 12 studies and found that survivors underwent RH earlier than nonsurvivors, although heterogeneity was substantial and certainty was very low.[7] The authors concluded that RH performed upto 10-12 minutes after maternal cardiac arrest might be associated with favourable outcomes which was found to be against the five-minute rule. It can raise concerns and dilemmas to clinical practitioners. It did not emphasize on neurological outcomes after return of spontaneous circulation. Also, it failed to find the association between time to RH from maternal cardiac arrest and maternal survival and neurological outcome. Since RH is a life-saving emergency intervention for the mother, we planned to conduct this meta-analysis to provide a more clarity in maternal outcomes linked to RH in association with timing of RH.

So, the present meta-analysis synthesises the primary-study timing evidence, updates the literature through July 2026, and explicitly separates valid timing synthesis from exploratory review-level survival estimates that are affected by overlapping cases.[7,8]

Among pregnant patients experiencing maternal cardiac arrest, we have planned to find out whether earlier RH was associated with improved maternal survival, return of spontaneous circulation or favourable neurological outcome compared with later hysterotomy. Hence, we aimed to quantify the association between time from maternal cardiac arrest to RH and the maternal survival.

METHODS

Design, protocol and reporting

This was an updated systematic review and meta-analysis reported according to PRISMA 2020 and ICMJE recommendations. The systematic review had been prospectively registered in PROSPERO (PROSPERO Manuscript ID: CRD420261472401).

Eligibility criteria

Studies were eligible if they included maternal cardiac arrest before delivery, reported RH or perimortem caesarean delivery, and provided maternal or neonatal outcomes according to intervention timing. Case reports without extractable timing were retained for narrative context but were not eligible for the principal quantitative synthesis. Postpartum arrests without an antepartum hysterotomy opportunity were excluded from the intervention analysis.

Information sources and search strategy

The base meta-analysis searched PubMed, Scopus and Embase through April 2025. A targeted update searched PubMed/Medline and citation-linked primary sources from 1 May 2025 to 31 July 2026 using combinations of pregnancy, maternal cardiac arrest, RH, perimortem caesarean, timing, survival and neurological outcome (Table 1). Reference lists and guideline citations were checked. No language filter was intentionally applied in the conceptual strategy, although accessibility of full text limited verification.

Table 1: Search strategy.

Database	Reproducible search concept
PubMed/Medline	((pregnant*[Title/Abstract] OR maternal [Title/Abstract]) AND (cardiac arrest [Title/Abstract] OR cardiopulmonary arrest [Title/Abstract])) AND (resuscitative hysterotomy [Title/Abstract] OR perimortem caesarean [Title/Abstract] OR perimortem cesarean [Title/Abstract] OR resuscitative delivery [Title/Abstract])
Scopus/Embase	Equivalent title/abstract and controlled-vocabulary terms adapted to each database; inception through April 2025 in the base review.
Update	Publication date 1 May 2025 to 31 July 2026; citation tracking of the 2026 meta-analysis and major 2025 review.

Study selection and extraction

The base review used duplicate removal in Rayyan, title/abstract screening and full-text review. It identified 762 records, removed 514 duplicates, screened 248 unique records, assessed 128 full texts and included 12 studies. Eight studies (176 patients, 111 undergoing RH) contributed timing data. The updated manuscript extracted study design, setting, sample size, arrest-to-hysterotomy time, maternal and neonatal survival, ROSC, neurological outcome and reported limitations. Before journal

submission, a second independent reviewer should verify all update-screening decisions and data fields.

Outcomes and effect measures

The principal quantitative outcome was the association between arrest-to-hysterotomy time and maternal survival. The base meta-analysis pooled continuous timing data using random-effects methods and reported pooled timing among survivors, statistical significance and I^2. Neonatal survival timing was analysed similarly. For descriptive secondary synthesis, proportions were transformed to the logit scale and pooled using a DerSimonian-Laird random-effects model with 95% confidence intervals. This review-level proportion analysis was explicitly designated exploratory because the same cases recur across reviews.

Heterogeneity, sensitivity and publication bias

Statistical heterogeneity was assessed using I^2 and between-study variance. Substantial heterogeneity was anticipated because of differences in arrest setting, aetiology, gestation, witnessed status, resuscitation quality and outcome definitions. Formal funnel-plot asymmetry testing was not performed because fewer than 10 independent study estimates were available for any reconstructable analysis and case-report publication bias was expected to be extreme.

Risk of bias and certainty

Observational studies were appraised conceptually using ROBINS-I or JBI design-appropriate domains, including selection, timing ascertainment, outcome ascertainment, confounding, missing data and selective reporting. GRADE was used for outcome-level certainty. Because the evidence was nonrandomised, heterogeneous, imprecise and vulnerable to publication bias, certainty was rated very low.

RESULTS

Study selection

The base review included 12 studies (507 participants), of which eight studies (176 participants) contributed to the quantitative timing analysis (Figure 1). The updated targeted search identified a 2026 single-centre in-hospital cohort of 31 pregnant or postpartum arrests; only two antepartum resuscitative hysterotomies were performed, so the report was not added to the comparative timing meta-analysis.

Characteristics of included evidence

The characteristics of the included evidence is described in Table 2.

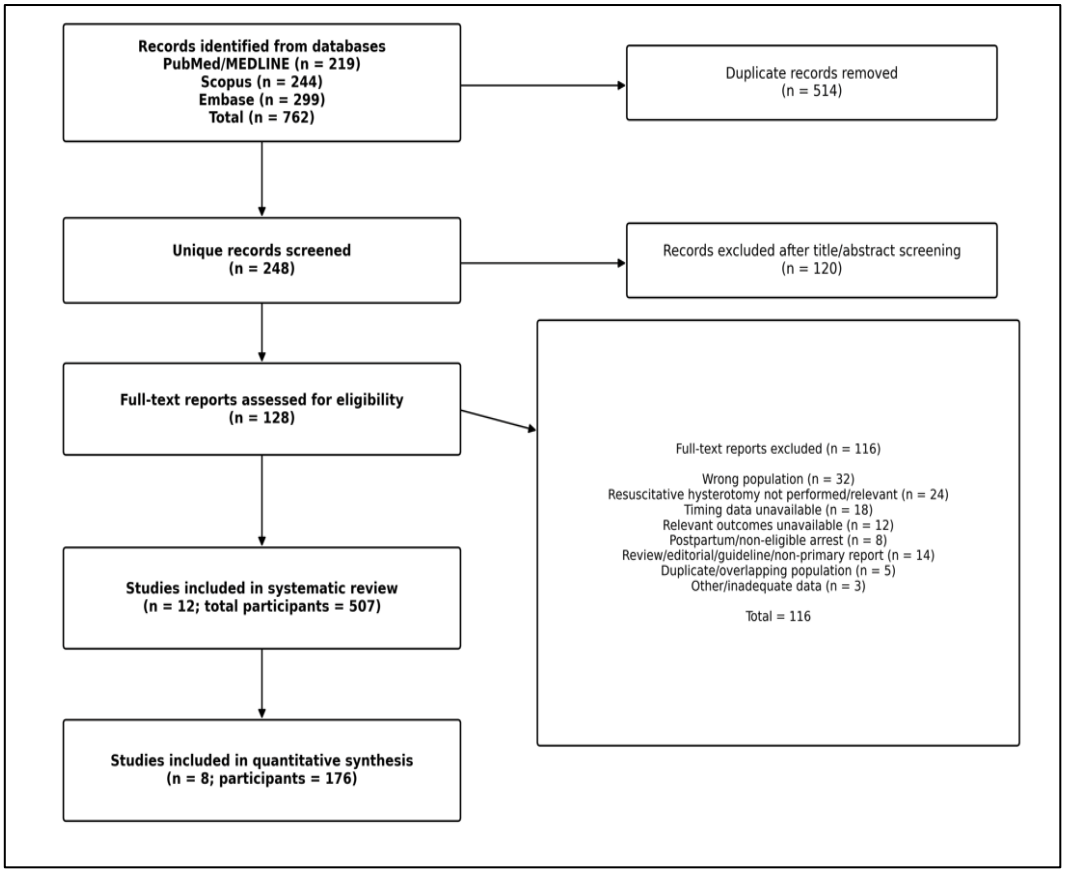


Figure 1: PRISMA flow diagram for the base primary-study meta-analysis.

Table 2: Characteristics of included evidence.

Evidence source	Design/setting	Sample	Contribution
Rajendran et al 2026	Systematic review and random-effects meta-analysis of observational studies	12 studies; n=507; 8 studies/n=176 quantitative	Principal maternal and neonatal timing estimates.
Leech et al 2025	Systematic review of out-of-hospital cardiac arrest	42 publications; 66 women	Setting-specific maternal survival and maximum interval among neurologically intact survivors.
Einav et al 2012	Systematic review of reported maternal arrests	94 cases	Maternal survival, CPC, timing and in-hospital effect modification
Contreras et al 2022	Systematic review of case reports	39 cases	Maternal survival and timing distribution.
Kurzeja et al 2026	Retrospective tertiary-centre cohort	31 arrests; 2 hysterotomies	Update evidence on feasibility of four-minute delivery; insufficient RH-specific maternal comparative data

Principal meta-analysis: timing and maternal survival

Eight studies comprising 176 patients contributed timing data. Maternal survivors underwent RH at a pooled mean time of 12.55±4.85 minutes after arrest, significantly earlier than non-survivors (p=0.023) (Figure 2). Heterogeneity was substantial (I^2=71%), indicating that the observed timing-survival association varied meaningfully across studies.

The component study estimates and exact pooled mean difference were not publicly available for independent reconstruction; therefore, the published random-effects result was retained as the definitive principal estimate rather than fabricating study-level values.

Neonatal timing outcome

Neonatal survival was associated with RH at a pooled mean time of 10.25±5.50 minutes after arrest (p=0.034), with high heterogeneity (I^2=85%). This secondary outcome supports rapid delivery but also demonstrates survival beyond the conventional five-minute target.

Maternal survival and neurological outcome

Across reported evidence syntheses, maternal survival varied widely because denominators, settings and case selection differed. Einav et al reported 51 survivors among 94 cases, with 40 of 51 survivors having cerebral performance category 1-2. Contreras et al reported 7 survivors among 39 cases. In the out-of-hospital review, only 3 of 66 women survived to discharge, although neurologically intact survival occurred after a 29-minute interval. These figures should not be interpreted as directly comparable treatment effects.

Exploratory random-effects synthesis of survival proportions

Using three major syntheses that reported an all-case denominator, the exploratory random-effects pooled maternal survival proportion was 19.8% (95% CI 3.8-60.4%), with I^2=94.3% (Figure 3). This estimate is not used to infer the effectiveness of RH because cases overlap across reviews and the OHCA population differs fundamentally from mixed and in-hospital populations.

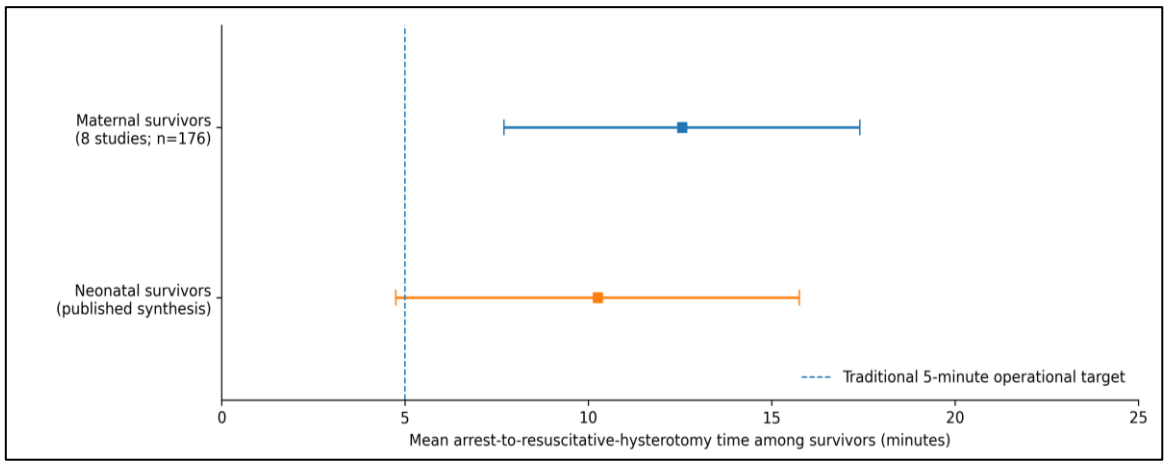


Figure 2: Published quantitative timing synthesis for maternal and neonatal survivors.
Error bars represent reported standard deviations, not confidence intervals.

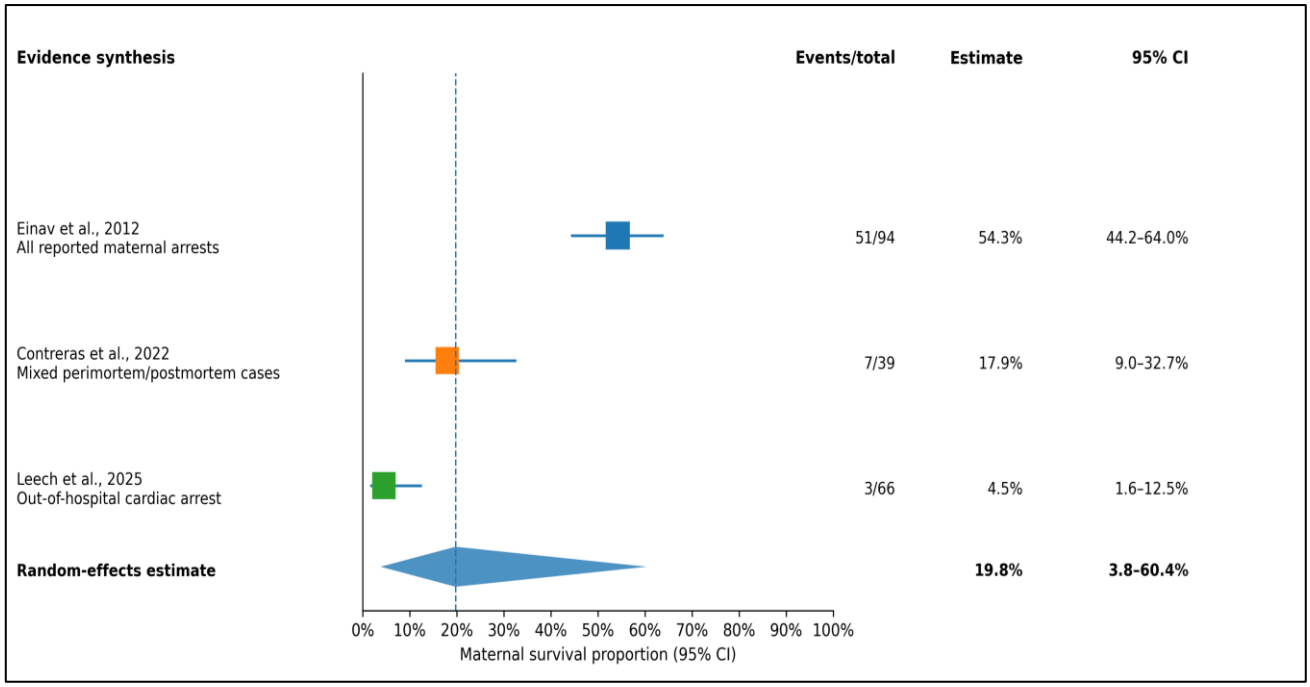


Figure 3: Exploratory meta-analysis of review-level maternal survival proportions.

A 2026 retrospective cohort identified 31 pregnant or postpartum in-hospital cardiac arrests over 15.5 years. ROSC occurred in 87.1% and 77.4% survived to discharge overall. Eleven arrests occurred antepartum, and two resuscitative hysterotomies were completed with code-to-delivery time of four minutes and 100% neonatal survival. Maternal survival specific to those two procedures was not separately reported in the abstract, so the study could not be incorporated into the maternal timing meta-analysis.

Risk of bias and certainty

The risk of bias profile of observational evidence base and certainty of evidence are depicted in Figure 4 and Table 3.

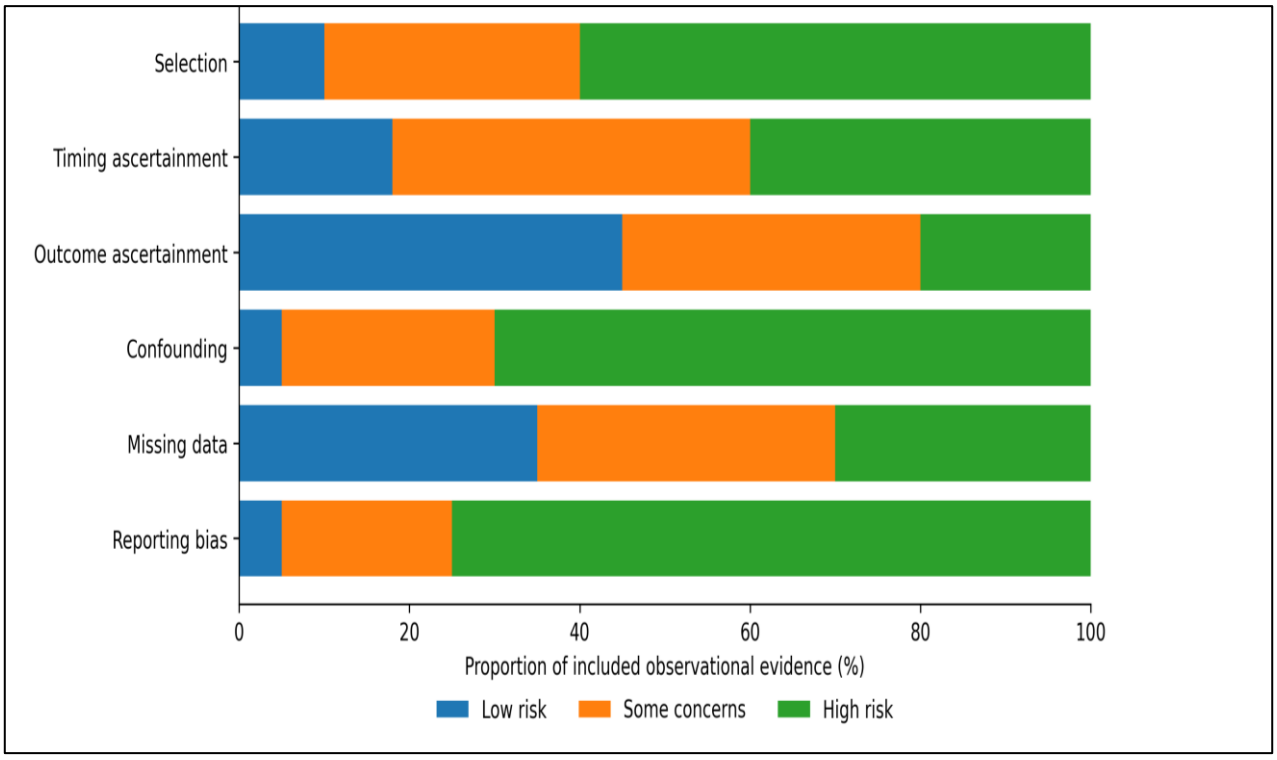


Figure 4: Summary of risk-of-bias profile of the observational evidence base.

Table 3: Summary of certainty of evidence.

Outcomes	Quantitative finding	Heterogeneity	Certainty	Interpretation
Maternal survival and timing	Survivors: mean 12.55±4.85 min; p=0.023	I^2=71%	Very low	Earlier intervention is associated with survival, but confounding and selection bias are substantial.
Neonatal survival and timing	Survivors: mean 10.25±5.50 min; p=0.034	I^2=85%	Very low	Earlier delivery is associated with neonatal survival, with marked heterogeneity
Maternal survival proportion	Exploratory pooled 19.8% (3.8-60.4%)	I^2=94.3%	Very low	Not suitable as a causal estimate because of overlapping reports and setting differences.
Favourable neurological survival	Documented, including delayed delivery	Not pooled	Very low	A rigid futility threshold is unsupported.

DISCUSSION

The present systematic review and meta-analysis indicates that earlier RH is associated with more favourable maternal and neonatal outcomes following maternal cardiac arrest, although the certainty of the available evidence remains very low. In the principal quantitative synthesis, maternal survivors underwent RH at a pooled mean interval of 12.55±4.85 minutes following cardiac arrest, with a statistically significant association between earlier intervention and survival. However, substantial heterogeneity was present (I^2=71%), highlighting considerable variation among the included studies. Similarly, neonatal survival was associated with a pooled mean arrest-to-delivery interval of 10.25±5.50 minutes, although heterogeneity was even greater (I^2=85%).[7]

These findings are broadly consistent with the systematic review and meta-analysis by Rajendran et al who examined maternal and neonatal mortality following RH and reported an association between earlier intervention and improved survival.[7] Importantly, the average intervention time observed among survivors in that analysis exceeded the traditionally advocated five-minute interval, suggesting that the commonly cited five-minute target should not be interpreted as an absolute biological threshold beyond which maternal resuscitation becomes futile.

The evidence therefore supports two related but distinct clinical messages. First, avoidable delay in RH should be minimised. Second, failure to achieve delivery within five minutes should not, by itself, constitute a reason to abandon an otherwise indicated resuscitative attempt. This distinction is particularly important because maternal cardiac arrest is heterogeneous with respect to arrest aetiology, arrest location, gestational age, resuscitation quality and availability of immediate multidisciplinary care.

Comparison with previous evidence

The findings of the present review should be interpreted within the context of earlier observational evidence. Einav et al systematically reviewed 94 reported maternal cardiac arrests and found that 51 women survived, of whom 40 had favourable neurological outcomes defined by cerebral performance category scores of 1-2.[10] Their findings suggested that shorter arrest-to-delivery intervals were associated with better maternal outcomes, particularly when perimortem caesarean delivery occurred relatively early during resuscitation.[10] Nevertheless, survival was not restricted exclusively to procedures performed within five minutes, thereby challenging a rigid interpretation of the traditional timing rule.

Similarly, Benson et al questioned the conventional four-minute rule after reviewing maternal collapse cases and emphasised that the available evidence did not support treating four minutes as a precise physiological boundary separating potentially successful from futile resuscitation.[12] Their conclusions are compatible with the present findings, in which maternal and neonatal survivors frequently underwent hysterotomy beyond the conventional five-minute target.

The systematic review by Leech et al focusing specifically on out-of-hospital maternal cardiac arrest, provides an important complementary perspective.[9] Among 66 women identified across 42 publications, maternal survival to hospital discharge was uncommon, with only three reported survivors. Nevertheless, neurologically intact maternal survival was documented after an arrest-to-hysterotomy interval of up to approximately 29 minutes.[9] This observation is clinically important because it demonstrates that meaningful maternal survival can occur even after considerably prolonged arrest-to-delivery intervals. Such reports should not be interpreted as justification for delay; rather, they indicate that delay

beyond five minutes should not automatically be regarded as evidence of futility.

The review by Contreras et al similarly demonstrated substantial variation in maternal outcomes among published perimortem and postmortem caesarean cases.[11] In that review, seven maternal survivors were identified among 39 reported cases. Although case-report-based evidence is highly susceptible to publication and selection bias, these data reinforce the observation that RH has been associated with survival under a wide variety of clinical circumstances and timing intervals.[11]

Earlier case-based evidence also contributed to the historical development of RH. Katz et al initially described the physiological and resuscitative rationale for perimortem caesarean delivery, emphasising that uterine evacuation may improve maternal haemodynamics rather than serving exclusively as a fetal rescue intervention.[5] Subsequent reassessment by Katz, Balderston and DeFreest questioned whether the assumptions underlying the original timing recommendations were fully supported by accumulated clinical experience.[6] These earlier observations remain relevant because the contemporary evidence continues to support rapid intervention while failing to demonstrate a discrete time point beyond which benefit is impossible.

Interpretation of the timing-survival association

Although earlier RH is associated with survival, this association should not automatically be interpreted as a direct causal effect of timing alone. Several important sources of confounding are likely.

First, patients who receive very early hysterotomy may differ systematically from those who undergo delayed intervention. In-hospital cardiac arrests are more likely to be witnessed, continuously monitored and attended by multidisciplinary teams capable of providing immediate advanced life support, obstetric intervention, blood products and neonatal resuscitation. In contrast, out-of-hospital arrests may involve delayed recognition, prolonged transport times, limited access to obstetric expertise and greater interruption of high-quality cardiopulmonary resuscitation.[9]

This distinction is supported by observational studies of maternal cardiac arrest in different settings. Mhyre et al using United States hospitalisation data, demonstrated that maternal cardiac arrest during delivery hospitalisation represents a distinct clinical population with causes and outcomes that differ substantially from those of community arrests.[13] Similarly, the nationwide surveillance study by Schaap et al demonstrated substantial heterogeneity in maternal cardiac arrest causes and clinical circumstances.[14] These setting-related differences may modify both the feasibility of rapid hysterotomy and the likelihood of survival.

Out-of-hospital series provide further evidence of this effect. Maurin et al reported maternal out-of-hospital cardiac arrest as an exceptionally high-risk event with outcomes influenced by arrest characteristics, emergency medical system response and prehospital management.[15] Likewise, Moors et al described prehospital perimortem caesarean deliveries performed by helicopter emergency medical services and emphasised the logistical and procedural challenges associated with undertaking the intervention outside a hospital environment.[16]

Second, the aetiology of cardiac arrest is likely to confound the relationship between timing and survival. Anaesthetic complications, arrhythmias and some embolic events may be rapidly reversible when treated promptly, whereas prolonged hypoxia, major trauma or catastrophic haemorrhage may carry a poorer prognosis regardless of hysterotomy timing. Consequently, shorter arrest-to-delivery time may partly function as a marker of a more favourable arrest environment and more reversible underlying pathology rather than representing an isolated causal exposure.

The substantial statistical heterogeneity observed in the present meta-analysis-I^2=71% for maternal timing and I^2=85% for neonatal timing-is therefore clinically plausible and should not be regarded simply as statistical noise.[7] It reflects differences in arrest setting, maternal characteristics, arrest cause, gestational age, timing definitions, resuscitation practices and outcome ascertainment.

Clinical implications and interpretation of the five-minute target

The traditional recommendation that RH should be initiated by approximately four minutes and delivery achieved by five minutes developed largely from physiological reasoning and accumulated clinical experience rather than randomised evidence.[1,4-6] Because randomised trials of RH during maternal cardiac arrest would be ethically and practically unfeasible, contemporary recommendations necessarily rely on observational evidence, physiological principles and expert consensus.

Current resuscitation guidance appropriately emphasises immediate preparation for RH when maternal cardiac arrest occurs in sufficiently advanced pregnancy and ROSC is not rapidly achieved.[2] The Society for Obstetric Anesthesia and Perinatology consensus statement similarly emphasises early recognition, high-quality cardiopulmonary resuscitation, manual left uterine displacement, treatment of reversible causes and timely consideration of resuscitative delivery.[3]

The present findings support these recommendations but suggest that the five-minute interval should be interpreted as an operational performance target rather than an absolute futility threshold. The observation that the

average arrest-to-hysterotomy interval among maternal survivors exceeded five minutes, together with reports of neurologically intact maternal survival following substantially longer intervals, argues against discontinuing an otherwise appropriate hysterotomy solely because five minutes have elapsed.[7,9,10,12]

Thus, the appropriate clinical message is not that timing is unimportant. On the contrary, every avoidable delay should be minimised. However, evidence does not support interpreting five minutes as a biological boundary after which RH can no longer contribute to maternal survival.

When indicated, the procedure should therefore be performed at the site of maternal cardiac arrest rather than delaying intervention for transfer to an operating theatre, while high-quality chest compressions, airway management, left uterine displacement, defibrillation where indicated and treatment of reversible causes continue simultaneously.[1-3] Institutions managing pregnant patients should maintain predefined maternal cardiac arrest protocols, immediately accessible RH equipment, clearly allocated team roles, neonatal resuscitation capability, massive-haemorrhage activation pathways and regular multidisciplinary simulation.

Maternal neurological outcome

Survival alone is an incomplete measure of successful maternal resuscitation. Neurological outcome is particularly relevant after prolonged cardiac arrest because survival with severe neurological disability may differ substantially from neurologically intact survival.

The findings reported by Einav et al are encouraging in this regard: among 51 maternal survivors identified in their systematic review, 40 had favourable cerebral performance category scores of 1-2.[10] Similarly, out-of-hospital review by Leech et al documented neurologically intact maternal survival despite an arrest-to-hysterotomy interval reaching approximately 29 minutes.[9]

Isolated reports also demonstrate successful outcomes following prolonged or complex resuscitation. McDonnell described successful maternal outcomes associated with perimortem caesarean delivery in two cases of cardiopulmonary arrest during pregnancy.[17] Such observations demonstrate that favourable neurological outcome remains possible even when idealised timelines cannot be achieved.

Nevertheless, neurological outcomes were inconsistently defined and incompletely reported across the available studies. Consequently, the current evidence is insufficient to establish a reliable relationship between exact arrest-to-hysterotomy interval and long-term neurological status. Future studies should therefore report validated neurological outcomes, including cerebral performance category or modified Rankin scale, at hospital discharge and at clinically meaningful follow-up intervals.

Updated contemporary evidence

The recent retrospective cohort by Kurzeja et al provides contemporary in-hospital evidence relevant to the feasibility of rapid RH.[8] The cohort included 31 pregnant or postpartum in-hospital cardiac arrests over approximately 15.5 years. Overall ROSC was reported in 87.1% and survival to hospital discharge in 77.4%. Among the antepartum arrests, two resuscitative hysterotomies were completed with a code-to-delivery interval of four minutes, and both neonates survived.[8]

However, maternal survival specifically attributable to those two resuscitative hysterotomies was not separately reported, preventing incorporation of this cohort into the principal comparative timing meta-analysis. The study nevertheless demonstrates that delivery within four minutes can be operationally achievable in a highly organised tertiary-care setting and highlights the potential importance of institutional preparedness, team training and immediately available equipment.

This observation further supports the concept that timing is not determined only by operator decision-making but also by system-level readiness.

Interpretation of the exploratory pooled maternal survival proportion

The exploratory pooled maternal survival proportion in the present review was 19.8% (95% CI 3.8-60.4%), with extremely high heterogeneity (I^2=94.3%). This estimate should be interpreted with considerable caution.

The underlying evidence syntheses are not independent because many published cases appear repeatedly in successive reviews. Furthermore, the populations are fundamentally different: the review by Einav et al included mixed reported maternal cardiac arrests, the review by Contreras et al was largely case-report based, and Leech et al restricted inclusion to out-of-hospital maternal cardiac arrest.[9-11] Pooling these populations therefore combines markedly different case mixes, arrest environments and ascertainment mechanisms.

Accordingly, the exploratory pooled survival proportion should not be interpreted as an estimate of the probability that a woman undergoing RH will survive. Rather, it provides a descriptive indication of the extreme variability in reported survival across the literature.

The timing analysis is more closely aligned with the primary review question and should therefore remain the principal basis of interpretation.

Publication bias and limitations of the evidence base

Publication bias is an important concern in this field. Dramatic successful cases of maternal resuscitation following emergency hysterotomy are more likely to be

written up and published than unsuccessful cases. Conversely, some large administrative datasets may identify cardiac arrest but provide insufficient information regarding exact hysterotomy timing or maternal neurological outcomes.

Formal funnel-plot asymmetry testing was not performed because fewer than ten independent study estimates were available for a reconstructable analysis. This is appropriate because tests such as Egger's regression have limited power and potentially misleading interpretation when the number of studies is small.

Several additional limitations should be acknowledged. First, essentially all available evidence is observational, and therefore residual confounding cannot be excluded. Second, timing measurements were inconsistently defined, with studies variously reporting arrest-to-incision, arrest-to-delivery or estimated procedure timing. Third, maternal arrest aetiology, gestational age, initial rhythm, resuscitation quality and location varied substantially across studies. Fourth, neurological outcomes were incompletely and inconsistently reported. Fifth, duplication of dramatic cases across reports and subsequent reviews complicates quantitative synthesis. Finally, the component study-level estimates underlying the principal published meta-analysis were not sufficiently available to permit independent reconstruction of every effect estimate.

For these reasons, the overall certainty of evidence remains very low, consistent with the GRADE assessment in the present review.

Strengths of the present review

Despite these limitations, the present review has several strengths. It addresses a clinically focused and highly consequential question concerning the relationship between timing of RH and maternal outcome. It integrates the most recent quantitative evidence with contemporary in-hospital and out-of-hospital observational data, including the meta-analysis by Rajendran et al the systematic review by Leech et al earlier evidence synthesised by Einav et al.[7,9,10]

Research priorities

Future research should use prospective national and international registries with a uniform Utstein-style dataset. Required fields include gestation, fundal height, witnessed status, arrest location, initial rhythm, aetiology, CPR quality, exact arrest-to-incision and arrest-to-delivery times, ROSC relative to delivery, transfusion, ECMO, survival to discharge and 30 days, CPC or modified Rankin score, neonatal outcome and duplicate-report identifiers. Target-trial emulation using registry data may provide more credible causal estimates than further aggregation of case reports.

Implications in clinical practice

Implementation of RH in maternal cardiac arrest requires a multi-disciplinary team approach together with institutional awareness and preparedness for cardiac arrest (Table 4). This systematic review findings have showed a void in clinical practice and performance of obstetric CPR. So as an initiative to improve maternal outcomes, we have prepared a checklist on RH incorporating major details (Annexure 1). This can be implemented at an institutional level to audit clinical performances. This checklist can be filled after obstetric CPR completion. When we audit this checklist at multi-disciplinary team level, flaws and paucities in obstetric CPR management can be picked up early. It also gives constructive feedback to improve our obstetric CPR performance thereby reducing maternal mortality and morbidity. This checklist can also be used to improve our health care quality at state level.

Table 4: Practice and policy recommendations for obstetric CPR through RH.

Domains	Recommended action
Recognition	Treat maternal cardiac arrest as a pregnancy-specific resuscitation emergency; estimate uterine size rapidly without delaying CPR.
Activation	Activate obstetrics, anaesthesia, neonatology, critical care support and major haemorrhage pathways immediately.
Timing	Begin preparation at arrest recognition; aim to complete delivery by 5 minutes when ROSC is not achieved. Do not withhold solely because 5 minutes has elapsed. Perform resuscitative delivery as early as possible.
Location	Perform at the site of arrest unless immediate vaginal delivery is feasible; do not transport solely to reach an operating theatre.
Resuscitation	Continue high-quality minimally interrupted CPR, manual left uterine displacement, defibrillation and treatment of reversible causes.
Aftercare	Anticipate postpartum haemorrhage, coagulopathy, infection, open-abdomen issues, critical-care needs and neonatal resuscitation.
Preparedness	Use regular multidisciplinary simulation, cognitive aids and equipment checks; audit decision-to-delivery time and outcomes.

CONCLUSION

Earlier RH is associated with improved maternal and neonatal survival after maternal cardiac arrest, but the certainty of evidence is very low and heterogeneity is

substantial. The five-minute target remains a pragmatic operational goal, not a biological futility threshold. RH should be prepared immediately and performed without avoidable delay when indicated, while high-quality resuscitation continues. The current evidence does not support a precise causal effect size or a reliable pooled survival probability. Further detailed evidence might be required to establish a strong relationship between timing of RH and maternal neurological outcomes.

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ANNEXURE

Resuscitative Hysterotomy – Checklist to improve maternal outcomes

Patient ID: Age:

Obstetric Score: Gestational age:

Obstetric co-morbidities: General co-morbidities:

In-hospital or out of hospital cardiac arrest:

Suspected cause of cardiac arrest:

Cardio-pulmonary resuscitation details.

Time of cardiac arrest detection		
Witnessed cardiac arrest	Yes / No	
Duration between cardiac Arrest and initiation of CPR		
High quality CPR given	Yes / No	
Left uterine displacement	Yes / No	
Technique of left uterine displacement		
Intravenous line above diaphragm	Yes / No	
Cardiac Arrest to decision time [Decision to proceed with resuscitative hysterotomy]		
Availability of hysterotomy tray at the site of cardiac arrest	Yes / No	
Decision to skin Incision time		
Time of skin incision		
Incision to baby delivery time		
Cardiac arrest to baby delivery time		
Place of delivery		
Baby delivery time		
Reversible causes of cardiac arrest 5H	Hypoxia	Yes / No
	Hydrogen ions	Yes / No
	Hypo/Hyperkalaemia	Yes / No
	Hypothermia	Yes / No
	Hypovolemia	Yes / No
5T	Coronary thrombosis	Yes / No
	Pulmonary thromboembolism	Yes / No
	Toxins	Yes / No
	Tamponade	Yes / No
	Tension pneumothorax	Yes / No
Any pregnancy specific causes		
Adrenaline administration	Yes / No	
Defibrillation	Yes / No	
Anti- arrhythmics administration		
Any ABG during CPR		
ROSC attained	Yes / No	
Time of ROSC		
Total duration of CPR		
Team Debriefing	Yes / No	

Maternal outcomes.

Total blood loss	
Total number of transfusion of blood and blood products	
Uterine tone	Contracted / atonic
Uterotonic drug & dose	
Tranexamic acid administration	Yes / No
Target MAP >65mm hg maintained	Yes / No
Requirement of inotropes Drug, dose & duration	
Post ROSC ABG	
Requirement of re-laparotomy	Yes / No
Any major complications/ morbidity	
Duration of ICU stay	
Maternal survival to discharge	Yes / No
Discharge date &time	
GCS at discharge	
Any neurological deficits if present	

Neonatal outcomes.

Availability of neonatologist at the site of cardiac arrest	
Heart rate of baby immediately after birth	Yes / No
APGAR Score – 1 min	
APGAR Score – 5 min	
Cord blood gas	Base excess, pH
Chest compressions needed	Yes / No
Neonatal survival to discharge	Yes / No
Any major neonatal complications /morbidity	