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The effect of alternative methods of cardiopulmonary resuscitation – cough CPR, percussion pacing or precordial thump – on outcomes following cardiac arrest. A systematic review.

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Abstract

Background: Cardiopulmonary resuscitation (CPR) improves cardiac arrest survival. Cough CPR, percussion pacing and precordial thump have been reported as alternative CPR techniques. We aimed to summarise in a systematic review the effectiveness of these alternative CPR techniques.

Methods: We searched Ovid MEDLINE, EMBASE and the Cochrane Library on 24/08/2020. We included randomised controlled trials, observational studies and case series with five or more patients. Two reviewers independently reviewed title and abstracts to identify studies for full-text review, and reviewed bibliographies and 'related articles' (using PubMed) of full-texts for further eligible studies. We extracted data and performed risk-of-bias assessments on studies included in the systematic review. We summarised data in a narrative synthesis, and used GRADE to assess evidence certainty.

Results: We included 23 studies (cough CPR n=4, percussion pacing n=4, precordial thump n=16; one study studied two interventions). Only two (both precordial thump) had a comparator group ('standard' CPR). For all techniques evidence certainty was very low. Available evidence suggests that precordial thump does not improve survival to hospital discharge in out-of-hospital cardiac arrest. The review did not find evidence that cough CPR or percussion pacing improve clinical outcomes following cardiac arrest.

Conclusion: Cough CPR, percussion pacing and precordial thump should not be routinely used in established cardiac arrest. In specific inpatient, monitored settings cough CPR (in conscious patients) or percussion pacing may be attempted at the onset of a potential lethal arrhythmia. These must not delay standard CPR efforts in those who lose cardiac output.

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Introduction

Worldwide, around one in ten people will survival to hospital discharge following out-of-hospital cardiac arrest (OHCA) (1, 2). In children, OHCA survival estimates range from 1-20%, with children and adolescents having better survival than infants (< 1 year old) (3). Survival from in-hospital cardiac arrest (IHCA) may be as high as 25% (4-6). Chest compressions are a key component of standard approaches to cardiopulmonary resuscitation (CPR) and can improve survival (7).

There is some evidence that 'cough CPR' – a deep breath followed by forceful, repeated coughing every few seconds if one senses an arrhythmia – increases aortic, left atrial and left ventricular pressures (8). Cough CPR is a temporising measure before definitive treatment of the arrhythmia that can only be performed by cooperative, conscious patients. It requires that a patient recognise an acute onset of arrhythmia and act upon it before they lose consciousness, and so has no role in established cardiac arrest. There are periodic stories, often on social media, instructing members of the public to perform cough CPR, in order to 'survive a heart attack when alone'. In these reports, 'heart attack' is used erroneously in place of 'cardiac arrest'(9). Indeed, the term 'cough CPR' itself is a misnomer as it is a proposed treatment that cannot be carried out once the patient has sustained a cardiac arrest. Cough 'pacing' may be a more accurate description of the manoeuvre.

A precordial thump is typically described as a single, firm impact delivered to the lower half of the sternum with the ulnar side of the fist from approximately 20cm. The mechanical force of the thump may directly stimulate stretch-activated ion channels in the myocardium, creating an electrical impulse whose timing serves to terminate a reentrant tachyarrhythmia (10). Alternatively, the force of the impulse may be transmitted to the heart as electrical energy analogous to a pacing stimulus or very low energy shock, referred to as electromechanical transduction (11). Percussion pacing is similar to a precordial thump but involves less forceful, repetitive and rhythmical impacts targeting the left sternal edge, whose intent is to generate an electrical complex with each impact. This may be used to pace a heart in asystole or extreme bradyarrhythmia (10).

These alternative techniques may possibly be currently used by healthcare professionals or lay rescuers, in either the in- or out-of-hospital setting. They may delay or be used as an alternative to chest compressions as part of 'standard CPR'. Their use was reviewed by the International Liaison Committee on Resuscitation (ILCOR) in 2010, but this did not take the form of a rigorous systematic review. At that time, ILCOR recommended: considering cough CPR only for use at the onset of ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT) in a witnessed, monitored setting; and considering a precordial thump for witnessed, unstable VT if a defibrillator was not immediately available. They did not recommend percussion pacing (12).

In this systematic review we aimed to determine whether these techniques, compared to standard means of delivering CPR using chest compressions, improved clinical outcomes following cardiac arrest.

Methods

ILCOR commissioned this systematic review, which followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (13) and ILCOR guidelines (14). The PRISMA checklist is provided in the supplementary material. We registered the protocol with the International Prospective Register of Systematic Reviews (PROSPERO) (CRD42019152925).

The review was based on the following PICOST (Population, Intervention, Comparator, Outcome, Study Design, Timeframe) question, formulated by ILCOR: In adults or children in cardiac arrest (out-of-hospital and in-hospital) **[P]** does the use of alternative methods of manual CPR (cough CPR, percussion pacing, precordial thump) **[I]**, compared with standard CPR **[C]**, improve outcomes (restoration of cardiac output/circulation, return of spontaneous circulation (ROSC), survival to 30 days or hospital discharge, survival with favourable neurological outcome) **[O]**. We considered both randomised controlled trials (RCTs) and non-randomised studies **[S]** published in any year **[T]**.

The ILCOR Basic Life Support Task Force prioritised outcomes as critical (survival with favourable neurological outcome, survival to 30 days or hospital discharge) and important (ROSC and restoration of cardiac output/circulation). We included studies published in any language that presented primary data, regardless of whether or not they included a comparator group. We excluded case series that reported on fewer than five patients, conference abstracts and trial protocols, manikin or simulation studies, narrative reviews, editorials, opinions with no primary data, animal studies and experimental or laboratory models.

An information specialist at the University of Warwick developed an electronic search strategy with input from GDP and CMS. There were separate search strategies for cough CPR, percussion pacing and precordial thump (see the **Electronic Supplementary Material)**. We initially conducted searches on 30th September 2019, and updated them on 24th August 2020 in Ovid MEDLINE (1946 to Week 3 August 2020), EMBASE Classic and EMBASE (1947 to Week 3 August 2020) and the Cochrane Library.

CMS uploaded article citations into EndNote (version X9, Clarivate Analytics, Philadelphia) – which automatically removed duplicates – and subsequently uploaded a deduplicated list of articles into the online, open-source systematic review software Rayyan (Qatar Computing Research Institute) (15). Two reviewers (KR and MS), independently and without knowledge or each other's initial selections, screened titles and abstracts to determine eligibility for full-text review, and manually removed any further duplicates that they identified. KR and MS resolved conflicts in discussion with CMS.

For each of the articles initially selected for full-text review RD reviewed the reference list, and identified up to 50 'related articles' using the 'related articles' feature of PubMed (United States National Library for Medicine). RD uploaded titles and abstracts of these subsequent articles to Rayyan, and KR and MS screened this secondary list to determine further articles eligible for full-text review.

CMS developed a data collection form recording: which of the three interventions was studied, year of publication, study setting, participant details and number (in

intervention and comparator group, if applicable), and outcomes (in intervention and comparator group, if applicable). Each full-text was initially reviewed in detail by two reviewers (from RD, KR and MS) who populated the data collection form or excluded the article, as appropriate. CMS performed periodic oversight and checking of this process. For foreign language articles we used translation tools in Microsoft Word to produce an English language version. No situations arose where we required further information from study authors or further translation services.

CMS and RD independently performed risk of bias assessments, and resolved differences by discussion. We based assessments for case series studies lacking a comparator on a tool developed by Murad et al. (16), which reports a risk of bias by asking eight questions across four domains: selection (one question), ascertainment (two), causality (four), and reporting (one). The risk of bias for a domain would be considered high unless all questions for that domain are answered 'yes'. For cohort studies we used the ROBINS-I (Risk Of Bias In Non-randomised Studies – of Interventions) tool (17). Risk of bias is stratified as low, moderate, serious and critical across seven domains, and overall. The risk of bias tools and assessments are available in the **Electronic Supplementary Material.**

We assessed the certainty of evidence for each of the outcomes using the GRADE (Grading of Recommendations, Assessment, Development and Evaluations) approach (18).

Data Analysis

We assessed studies for clinical (i.e. participants, interventions, and outcomes), methodological (i.e. study design or risk of bias) and statistical heterogeneity. We planned meta-analysis if we found homogenous data from more than one RCT or more than one observational study with a comparator group, otherwise we would present a narrative summary.

If the evidence was limited to case-series or other non-randomised study designs without a comparator group, we provided point estimates (numbers and percentages),

and an odds ratio (OR) with 95% confidence intervals (CI) if available, for the outcome(s) presented for each intervention.

Results

Following the search strategies we performed title and abstract review of 3001 articles, after duplicate removal. We excluded 2972 articles at this stage. We further excluded six of 29 articles following full-text review. **Figure 1** details this process.

We have reported key findings from each of the 23 included studies in either **Table 1** (for studies with standard CPR as a comparator group) or **Table 2** (for studies with no comparator group). One study (19) reported on both cough CPR and precordial thump and we have presented results for each intervention separately. **Table 3** shows the GRADE table, detailing certainty of evidence for each intervention and each reported outcome**.** Detailed risk of bias assessments for each study are available in the **Electronic Supplementary Material.**

1. Cough CPR

We identified four non-randomised studies, in which patients experienced a variety of different arrhythmias – VF, VT, high-degree AV blocks, severe sinus bradycardia and asystole. None compared cough CPR with standard CPR and all were in adult patients. One reported on survival to hospital discharge (19) and three on the restoration of cardiac output/circulation (8, 20, 21). In all studies, patients were instructed to cough at the onset of a potentially non-perfusing arrhythmia, before loss of consciousness and established cardiac arrest. In three studies patients were prompted after arrhythmias were recognised on continuous cardiac monitoring (8, 20, 21). In the other study patients were taught how to recognise prodromal symptoms (19).

Two of the four studies selectively reported on cases where cough CPR was initially successful in terminating the arrhythmia (8, 19), of which one subsequently reported survival to hospital discharge (19). Caldwell et al. (19) selectively reported successful cough CPR in six inpatients (all conscious VT) – from a cohort of both 5000 inpatients

and OHCA patients in a one-year period, all of whom who received intervention for VF or VT. All six survived to hospital discharge. Two of the six patients also had precordial thump and all received other resuscitation measures. Six of the seven cases reported by Niemann et al. (8) occurred in the cardiac catheterisation suite, the seventh in CCU. Marozsan et al. (21) reported on 11 cases of asystole and two VF (i.e. rhythms definitely associated with cardiac arrest) among 92 episodes of arrhythmia in the cardiac catheterisation suite – all remained conscious throughout. In the one out-of-hospital study, researchers trained patients with a history of loss of consciousness following a variety of arrhythmias (including asystole, VF and VT) to cough at the onset of symptoms they associated with impending loss of consciousness. Sixty six of 115 patients trained in the technique reported using it, but the cardiac rhythm at the time of symptoms was unknown. None lost consciousness, but 20% required additional medical treatment at the time (20).

There was no evidence that cough CPR improves clinical outcomes compared to standard CPR techniques. Using the GRADE criteria, we assessed that the risk of bias for all studies was very serious and the certainty of evidence for all reported outcomes was very low.

2. Percussion Pacing

We identified four non-randomised studies, in which patients experienced asystole or prolonged bradycardias. None compared percussion pacing with standard CPR. Two reported on survival to hospital discharge. In one of these studies 62/100 survived to hospital discharge (22), of whom 9 reverted were discharged home in sinus rhythm and 53 were discharged home with a permanent pacemaker inserted. In the second study 1/10 survived to hospital discharge (23).

One study selectively reported five patients achieving ROSC, three of whom required CPR and defibrillation (24), and one reported restoration of cardiac output/circulation (41/42 remained conscious throughout) (25). One included paediatric patients, although it is not clear how many (22). The study by Scherf et al. (23) predated the routine use of chest compressions for the treatment of cardiac arrest, and percussion pacing was often delivered late.

The available evidence is insufficient to determine whether percussion pacing has an effect on any of the clinical outcomes of interest in this review. Using the GRADE criteria, we assessed that the risk of bias for all studies was very serious and the certainty of evidence for all reported outcomes was very low.

3. Precordial thump

We identified 16 non-randomised studies. Only two of these made a comparison to standard CPR – both in the out-of-hospital setting – and both reported on survival to hospital discharge (26, 27). The study by Pellis et al. was the only one to include paediatric patients (27). Three other studies assessed survival to hospital discharge (19, 28, 29), one ROSC (30), and ten restoration of cardiac output/circulation (31-40). Only one of these ten (36) reported on rhythms other than VF or VT.

Studies comparing precordial thump to standard CPR

The first study examined Emergency Medical Services (EMS-) witnessed, monitored VF/VT OHCA of presumed cardiac cause in patients aged at least 16 years of age in Melbourne, Australia (2003-2011). There were 434 eligible OHCA, with outcome data available in 428 cases. There was no statistically significant difference in survival to hospital discharge between the group that received a precordial thump immediately at the onset of cardiac arrest and the group that received standard CPR only: 71% (73/103, one unknown) vs 70% (228/325, 5 unknown); OR 1.02 (95% CI 0.62-1.66), p=0.95. There was also no statistically significant difference in ROSC at any time between precordial thump-first and standard CPR group: 93% (96/103) vs 90% (292/325); OR 1.55 (95% CI 0.66-3.62), p=0.31. However, ROSC achieved immediately after precordial thump was significantly lower than immediately after defibrillation (4.9% vs 58%, p<0.0001). Rhythm deterioration into pulseless electrical activity (PEA) or asystole occurred at similar rates in the intervention and standard CPR groups (9.7% vs 12.3%, p=0.48) (26).

The second study examined 363 all-cause OHCA for which resuscitation was attempted in a region of north-east Italy (2004-2005). Researchers compared patients

for whom precordial thump was the first intervention that EMS performed and patients for whom EMS made standard CPR efforts only. There was no statistically significant difference in survival to hospital discharge between the precordial thump group and standard CPR group: 5.6% (8/144) vs 6.4% (14/219); OR 0.86 (95% CI 0.35-2.11), p=0.74. There was also no statistically significant difference in ROSC at any time between precordial thump-first and standard CPR group: 22% (31/144) vs 20% (43/219); OR 1.12 (95% CI 0.67-1.89), p=0.66. Only 4.2% (6/144) patients experienced any change in rhythm after precordial thump (27).

Both studies required review of EMS records and so relied on EMS staff self-reporting of precordial thump. The first examined VF/VT OHCAs (26) and the second OHCAs of any rhythm (27). The timing of the intervention relative to cardiac arrest onset al.so varied (the mean ambulance response time in the second study was more than nine minutes (27)). We judged that this heterogeneity precluded meta-analysis.

Most patients in the precordial thump (intervention) group in both studies would also have received standard CPR measures. In neither study were between-group differences in baseline characteristics adjusted for in statistical analyses.

Other studies

Only two studies explicitly stated that all patients had sustained a cardiac arrest at the time of the precordial thump (19, 30). VT can be associated with a pulse even if the patient has become unresponsive.

Three studies reported on survival to hospital discharge (19, 28, 29). Caldwell et al. (19) selectively reported an initially successful precordial thump in 19 patients among a cohort of 5000 in-patients and victims of OHCA who received resuscitation for a VF/VT cardiac arrest, across a one-year period (16 in-patients and 3 OHCA victims). Two of the in-hospital patients also received cough CPR at the onset of the cardiac arrest and all received other resuscitation measures. Gertsch et al. (28) reported that 9/14 patients with 19 episodes of VT survived to hospital discharge: 4/8 patients who were successfully cardioverted (by precordial thump) and 5/6 patients with unsuccessful cardioversion attempt(s). Many received other therapies for VT during

their in-patient stay. Four out of five cases reported by Rajagopalan et al. (29) were successful cardioverted by precordial thump (and two survived to hospital discharge) but one patient in VT deteriorated to VF immediately post thump.

Miller et al. (30) reported on 50 OHCA patients who all developed VT or VF at some point during the resuscitation effort and received a precordial thump. ROSC was achieved in 1/27 patients with VT and 12/23 with VF. In VT patients, 12/27 had no change in rhythm immediately post precordial thump, 3 had a "better" rhythm, and 12 a "worse" rhythm (either asystole, PEA or VF). In VF patients, 12/23 were immediately converted to a perfusing rhythm.

All ten studies reporting on restoration of cardiac output/circulation occurred in in-hospital settings. Four studies reported on induced ventricular arrhythmias in an in-patient cardiology setting that could have been associated with a loss of cardiac output (31, 32, 35, 37). Three reported selectively on successful use of the precordial thump (n=39: 31 VT and 8 Adams-Stokes attacks) (36, 39, 40). In the remaining studies VT was terminated in 81/357 (23%) cases in 47/284 (29%) patients (from 7 studies (31-35) (37, 38); success rates in individual studies ranged from 0-61%) and VF in 0/59 patients (from three studies (31, 32, 34)). Two studies each described single cases in which a VT rhythm deteriorated into VF (29, 39).

The available evidence suggests that a precordial thump – compared to standard CPR – does not improve survival to hospital discharge or ROSC in OHCA. There is insufficient evidence to determine whether precordial thump has a beneficial effect on any of the clinical outcomes of interest in this review in other settings. Using the GRADE criteria, we assessed that the risk of bias for all studies was very serious and the certainty of evidence for all reported outcomes was very low.

Discussion

This review found no evidence to support the routine use of cough CPR, percussion pacing or precordial thump as a safe and effective alternative to standard CPR in either adults or children sustaining an out-of-hospital cardiac arrest. There is indirect evidence that a precordial thump in a patient with VT might precipitate a worsening of

rhythm, though there is no evidence about whether or not this happens at a higher rate than for standard CPR.

We identified no randomised trials, and only two observational studies directly compared an intervention (precordial thump for out-of-hospital cardiac arrest in both cases) to standard CPR. For all three interventions, the risk of bias for all included studies was very serious and the certainty of evidence for all reported outcomes was very low.

Strengths and limitations

Much of the evidence that we have presented is not recent, with only four of the 23 included articles published in this century. International guidelines for cardiopulmonary resuscitation have been updated on a number of occasions since then, and these alternative methods of CPR may be even less relevant as the science and practice of 'standard' CPR improves. Although ILCOR considered this topic in 2010, we have presented a more comprehensive systematic review that has considered articles published in all languages. However, we judged the risk of publication bias to be high as many of the included studies were case series, and some only included successful uses of the intervention (see **Table 3**).

Many studies did not concern (or at least did not specify) established cardiac arrest patients – indeed, cough CPR is a self-performed manoeuvre and excludes this by definition. We felt it appropriate to include papers that reported arrhythmias that are associated with a loss of effective cardiac output. However, there may well be differences in patients with pulsed and pulseless VT (for example, the degree of metabolic or respiratory acidosis, or hypoxia) that could potentially affect the outcome of these alternative manoeuvres (35).

The majority of included studies were case series with no comparator group, which means that the level of certainty of the evidence contained within them is very low. We have used the tool suggested by Murad et al. to provide more information about methodological quality of these articles (16).

Although researchers generally described the techniques used well, there is the potential for differences across the studies and in clinical practice. There will doubtless be differences in the timing of the use of the precordial thump.

Clinical Implications

There are periodic stories (on social media for example) advocating for the use of cough CPR in the out-of-hospital setting. Whilst one study reported here addressed the use of cough CPR for prodromal symptoms in the out-of-hospital setting (20), this patient group was high-risk, trained in its use, and the cardiac rhythm at the time of symptoms and the risk of progression to cardiac arrest was unknown. Accepting the benefit of cough CPR for the general population would require us to accept that an untrained patient could reliably identify a cardiac arrest rhythm in time to initiate coughing to maintain a cardiac output. This seems highly unlikely. In the specific circumstance when there is an in-hospital, monitored (awake) patient it seems appropriate to consider cough CPR at the onset of a potentially lethal arrhythmia, but it must not delay or prevent other resuscitative measures (chest compressions, defibrillation) with proven efficacy. The ILCOR recommendations from 2010 (12) specified considering cough CPR for VF or pulseless VT only, but the limited very low certainty evidence we have presented here included its use for bradycardic and asystolic episodes.

The evidence for percussion pacing is limited to four case series, in patients with asystole or profound bradyarrhythmias. In 2010 ILCOR did not recommend percussion pacing in any circumstance (12), but the limited very low certainty evidence we have presented here suggests that cardiac output can be maintained if perfusion pacing is initiated very quickly after the onset of the arrhythmia. This would necessitate a patient being monitored and witnessed at the time of the arrhythmia. There is no evidence to determine whether or not this is any better than initiating chest compressions at the onset of cardiac arrest and we cannot make a determination about whether or not there is any clinical role for this in current practice.

It is possible that a precordial thump can interrupt a life-threatening VT and re-establish a perfusing rhythm, but there may be a risk of rhythm deterioration. It may

be less effective at treating VF than VT. There is also the concern that preparing for and delivering a precordial thump would delay the initiation of chest compressions or defibrillation. In 2010, ILCOR recommended considering a precordial thump for witnessed, unstable VT if a defibrillator was not immediately available (12). However, given the concerns we have identified and that there is no evidence of its superiority over conventional CPR methods, we believe it is reasonable to recommend against its use in all cardiac arrest settings.

ILCOR has updated its Consensus on Science with Treatment Recommendations (CoSTR) document for 2020 (41) and has made relevant recommendations about alternative methods of CPR based on the findings from this systematic review.

Conclusion

There/ is no evidence for cough CPR, percussion pacing or precordial thump in the management of established cardiac arrest. The priority should be prompt chest compressions and defibrillation. In specific inpatient settings in witnessed, monitored patients, cough CPR or percussion pacing can be tried at the onset of a potential lethal arrhythmia to try and prevent cardiac arrest, provided these efforts do not delay standard CPR efforts in those who lose cardiac output.

Contributors

The paper was first drafted by RD, with input from MS and KR. CMS revised and produced subsequent drafts. GDP devised the initial search strategy and critically reviewed the final manuscript.

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Conflict of interests

GDP and CMS have volunteer roles with ILCOR and Resuscitation Council UK.

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Legends for Figures and Tables

Figure 1: PRISMA flow diagram, adapted from Moher et al. (13)

Table 1: Characteristics and outcomes of included studies – those with comparison to standard CPR

Table 2: Characteristics and outcomes of included studies – those with no comparator group

Table 3: GRADE table

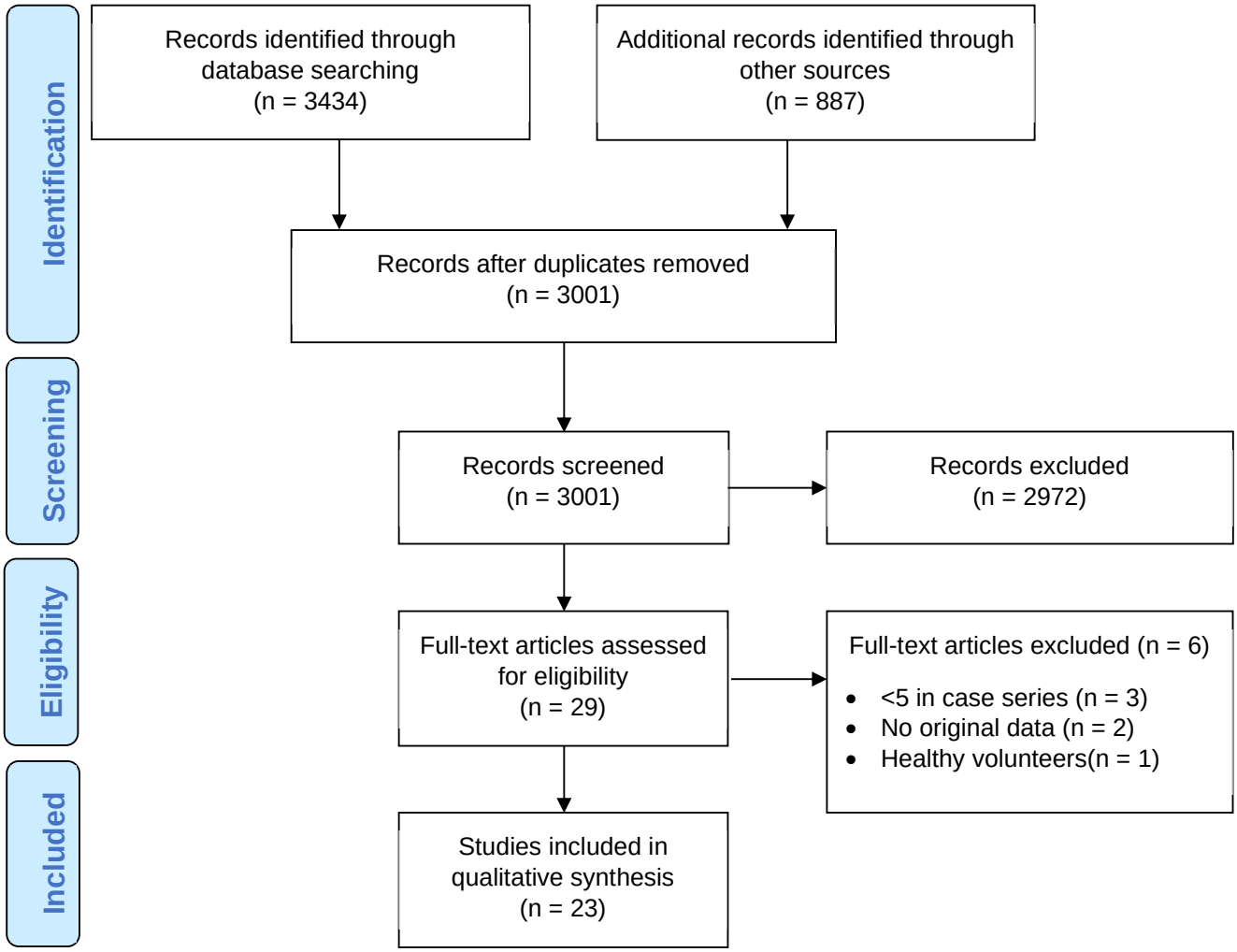

Figure 1: PRISMA flow diagram, adapted from Moher et al. (13)

Table 1: Characteristics and outcome of included studies – those with comparison to standard CPR

Intervention	Publication	Setting	Participants	Intervention group	Standard CPR (comparator group)	Primary outcome	Achieved outcome (intervention vs comparator)
Precordial Thump	Nehme 2013 (26)	Out-of-hospital	EMS-witnessed, monitored adult OHCA VF or VT, presumed cardiac cause	n=103 27 VT, 76 VF	n=325 96 VT, 229 VF	Survival to hospital discharge	71% (73/103) vs 70% (228/325)
	Pellis 2009 (27)	Out-of-hospital	All cause OHCA, any age All rhythms	n=144 24VF/VT, 42 PEA, 78 asystole	n=219 42 VF/VT, 59 PEA, 118 asystole	Survival to hospital discharge	5.6% (8/144) vs 6.4% (14/219) (p=ns)

Table 2: Characteristics and outcomes of included studies – with no comparator group

	Publication	Setting	Participants	Outcome	Main Findings
Cough CPR	Caldwell 1985 (19)	In-hospital	Six adults Conscious VT Age not reported*	Survival to hospital discharge	6/6 survived
	Petelenz 1998 (20)	Out-of-hospital	115 adults with history of collapse Cough CPR instructed if future prodromes Mean age 58	Restoration of cardiac output / circulation	365 events in 66 patients None lost consciousness
	Marozsan 1990 (21)	In-hospital	13 adults 11 asystole, 2 VF Mean age 47.8	Restoration of cardiac output / circulation	All remained conscious throughout
	Niemann 1980 (8)	In-hospital	Seven adults 4 VF, 2 asystole, 1 high degree A-V block Median age 45	Restoration of cardiac output / circulation	Selectively reported successful use of intervention
Percussion Pacing	Klumbies 1988 (22)	In-hospital	100 patients Asystole (n=89) or "life-threatening" bradycardia (n=11) Mean age 68 (11-84)	Survival to hospital discharge	62/100 survived
	Scherf 1960 (23)	In-hospital	11 adults “Ventricular standstill” Mean age 72.7	Survival to hospital discharge	1/10 survived (unclear outcome in one patient)
	Iseri 1987 (24)	In-hospital	5 adults Asystolic cardiac arrest Mean age 61.8	ROSC	Selectively reported successful use of intervention

	Paliege 1982 (25)	In-hospital	42 adults 35 asystole, 7 “extreme” bradycardia Age not reported	Restoration of cardiac output / circulation	41/42 maintained cardiac output
Precordial Thump	Gertsch 1992 (28)	In-hospital	19 VT in 14 adults Mean age 65	Survival to hospital discharge	9/14 survived
	Caldwell 1985 (19)	In-hospital (n=16) Out-of-hospital (n=3)	19 adults 4 VF, 11 VT, 2 asystole, 2 unknown Age not reported*	Survival to hospital discharge	9/16 in-hospital and 2/3 out-of-hospital survived
	Rajagopalan 1971 (29)	In-hospital	5 adults All VT Mean age 58.4	Survival to hospital discharge	2/5 survived
	Miller 1984 (30)	Out-of-hospital	50 adults 27 VT, 23 VF Age range 41-92	ROSC	11/27 ROSC in VT patients 12/23 ROSC in VF patients
	Haman 2009 (31)	In-hospital	155 adults Induced arrhythmias 134 VT, 21 VF Mean age 68	Restoration of cardiac output / circulation	Arrhythmia terminated in 2/155 (both VT)
	Amir 2007 (32)	In-hospital	80 adults 52 VT, 28 VF Mean/median (unclear) age 66	Restoration of cardiac output / circulation	Arrhythmia terminated in 1/80 (VT)
	Nejima 1991 (33)	In-hospital	27 adults All VT	Restoration of cardiac output / circulation	VT terminated in 28/46 episodes in 13/27 patients

	Volkmann 1990 (34)	In-hospital	23 adults 37 VT in 13 patients 10 VF in 10 patients Mean age 58.2	Restoration of cardiac output / circulation	VT terminated in 20/37 episodes in 13/13 patients VF terminated in 0/10
	Miller 1985 (35)	In-hospital	9 patients 11 induced, sustained VT Age not reported	Restoration of cardiac output / circulation	VT terminated in 0/11 episodes
	Cotoi 1980 (36)	In-hospital[+]	14 patients (unclear) Six VT, eight Adams-Stokes attacks Age not reported	Restoration of cardiac output / circulation	Selectively reported successful use of intervention
	Morgera 1979 (37)	In- hospital[+]	17 adults 45 VT Mean age 65	Restoration of cardiac output / circulation	VT terminated in 22/45 episodes in 10/17 patients
	Befeler 1978 (38)	In-hospital	32 adults All VT Age not reported	Restoration of cardiac output / circulation	VT terminated in 8/32
	Rahner 1978 (39)	In-hospital	20 adults All VT Mean age 61	Restoration of cardiac output / circulation	Selectively reported successful use of intervention
	Pennington 1970 (40)	In-hospital	5 adults 12 VT Age not reported	Restoration of cardiac output / circulation	Selectively reported successful use of intervention

[+] Presumed in-hospital from article descriptions, but not specified

* Age for patients receiving either cough CPR or precordial thump was mean 71 (range 51-83) years in the Caldwell paper (19) but age for each individual treatment not reported

Table 3: GRADE table

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Cough CPR; Percussion pacing; or Precordial thump	Standard CPR	Relative (95% CI)	Absolute (95% CI)		
Cough CPR: Survival to hospital discharge (in-hospital)												
1	observational studies	very serious [a]	not serious	very serious [g]	not serious	publication bias strongly suspected [b]	6/-	-	-	-	⊕◯◯◯ VERY LOW	CRITICAL
Cough CPR: Restoration of cardiac output / circulation (in-hospital)												
2	observational studies	very serious	not serious	very serious [g]	not serious	publication bias strongly suspected [b]	20/-	-	-	-	⊕◯◯◯ VERY LOW	IMPORTANT
Cough CPR: Restoration of cardiac output / circulation (out-of-hospital)												
1	observational studies	very serious [c]	not serious	very serious [g]	not serious	publication bias strongly suspected [b]	66/-	-	-	-	⊕◯◯◯ VERY LOW	IMPORTANT

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Cough CPR; Percussion pacing; or Precordial thump	Standard CPR	Relative (95% CI)	Absolute (95% CI)		
Percussion pacing: Survival to hospital discharge (in-hospital)												
2	observational studies	very serious	not serious	very serious [g]	not serious	publication bias strongly suspected [b]	111/-	-	-	-	⊕◯◯◯ VERY LOW	CRITICAL
Percussion pacing: ROSC (in-hospital)												
1	observational studies	very serious [c]	not serious	very serious [g]	not serious	publication bias strongly suspected [b]	5/-	-	-	-	⊕◯◯◯ VERY LOW	CRITICAL
Percussion pacing: Restoration of cardiac output / circulation (in-hospital)												
1	observational studies	very serious	not serious	very serious [g]	not serious	publication bias strongly suspected [b]	42/-	-	-	-	⊕◯◯◯ VERY LOW	IMPORTANT
Precordial thump: survival to hospital discharge (out-of-hospital, comparator group)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Cough CPR; Percussion pacing; or Precordial thump	Standard CPR	Relative (95% CI)	Absolute (95% CI)		
2	observational studies	very serious [d]	very serious [e]	not serious	not serious	none	791 patients with known outcomes. Heterogeneity in two included studies precludes meaningful combination of data - see Table 1 and results text for results from individual studies (26, 27)				⊕◯◯◯ VERY LOW	CRITICAL

Precordial thump: survival to hospital discharge (in-hospital)

3	observational studies	very serious	not serious	very serious [g]	not serious	publication bias strongly suspected [b]	35/-	-	-	-	⊕◯◯◯ VERY LOW	CRITICAL

Precordial thump: survival to hospital discharge (out-of-hospital)

1	observational studies	very serious	not serious	very serious [g]	not serious	publication bias strongly suspected [b]	3/-	-	-	-	⊕◯◯◯ VERY LOW	CRITICAL

Precordial thump: ROSC (out-of-hospital)

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Cough CPR; Percussion pacing; or Precordial thump	Standard CPR	Relative (95% CI)	Absolute (95% CI)		
1	observational studies	very serious	not serious	very serious [g]	not serious	publication bias strongly suspected [b]	50/-	-	-	-	⊕◯◯◯ VERY LOW	CRITICAL

Precordial thump: restoration of cardiac output / circulation (in-hospital)

10	observational studies	very serious [f]	very serious [f]	very serious [g]	not serious	publication bias strongly suspected [b]	382/-	-	-	-	⊕◯◯◯ VERY LOW	IMPORTANT

a. More than one intervention in some patients. Reported only cases where cough CPR initially successful in terminating arrhythmia
b. Literature limited to case series or cohorts with no comparator group. We judge it likely that there are negative results from centres that have not been published
c. Reported only successful use of intervention
d. Downgraded because of an overall critical risk of bias for both included studies as per ROBINS-I
e. Major differences in cardiac arrest rhythms and timing of intervention between the two studies included here
f. Heterogeneity, inconsistent results. Three studies only reported successful use of precordial thump
g. No comparator group