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

Authors

Ryan Dee[1], Michael Smith[1], Kausala Rajendran[1], Gavin D Perkins[1], Christopher M Smith[1]; on behalf of the International Liaison Committee on Resuscitation Basic Life Support Task Force Collaborators

Affiliations

[1] Warwick Medical School, University of Warwick, Coventry, CV4 7AL, UK

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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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References

1. Yan S., Gan Y., Jiang N., Wang R., Chen Y., Luo Z., et al. The global survival rate among adult out-of-hospital cardiac arrest patients who received cardiopulmonary resuscitation: a systematic review and meta-analysis. *Crit Care*. 2020;24:61.
2. Kiguchi T., Okubo M., Nishiyama C., Maconochie I., Ong M.E.H., Kern K.B., et al. Out-of-hospital cardiac arrest across the World: First report from the International Liaison Committee on Resuscitation (ILCOR). *Resuscitation*. 2020;152:39-49.
3. Shimoda-Sakano T.M., Schvartsman C., Reis A.G. Epidemiology of pediatric cardiopulmonary resuscitation. *Jornal de Pediatria* 2020;96:409-21.
4. Andersen L.W., Holmberg M.J., Berg K.M., Donnino M.W., Granfeldt A. In-Hospital Cardiac Arrest: A Review. *JAMA.* 2019;321:1200-10.
5. Benjamin E., Muntner P., Alonso A., al. e. Heart Disease and Stroke Statistics—2019 Update: Chapter 17. *Circulation.* 2019;139:e377-e400.
6. Nolan J.P., Soar J., Smith G.B., Gwinnutt C., Parrott F., Power S., et al. Incidence and outcome of in-hospital cardiac arrest in the United Kingdom National Cardiac Arrest Audit. *Resuscitation*. 2014;85:987-92.
7. Perkins G.D., Handley A.J., Koster R.W., Castrén M., Smyth M.A., Olasveengen T., et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 2. Adult basic life support and automated external defibrillation. *Resuscitation*. 2015;95:81-99.
8. Niemann J.T., Rosborough J., Hausknecht M., Brown D., Criley J.M. Cough-CPR: documentation of systemic perfusion in man and in an experimental model: a "window" to the mechanism of blood flow in external CPR. *Crit Care Med.* 1980;8:141-6.
9. Trethewey S.P. 'Cough CPR': Misinformation perpetuated by social media. *Resuscitation.* 2018;133:e7-e8.
10. Jeremy Rice J., Kohl P. Mechanoelectrical Interactions and Their Role in Electrical Function of the Heart. In: Gussak I, Antzelevitch C, Wilde AAM, Friedman PA, Ackerman MJ, Shen W-K, editors. Electrical Diseases of the Heart: Genetics, Mechanisms, Treatment, Prevention. London: Springer London; 2008. p. 145-60.
11. Tucker K.J., Shaburihvili T.S., Gedevanishvili A.T. Manual external (fist) pacing during high-degree atrioventricular block: A lifesaving intervention. *Am J Emerg Med*. 1995;13:53-4.
12. Koster R.W., Sayre M.R., Botha M., Cave D.M., Cudnik M.T., Handley A.J., et al. Part 5: Adult basic life support: 2010 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. *Resuscitation*. 2010;81 Suppl 1:e48-70.
13. Moher D., Liberati A., Tetzlaff J., Altman D.G., for the P.G. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ*. 2009;339:b2535.
14. International Liaison Committee on Resuscitation (2020). Continuous Evidence Evaluation Guidance and Templates. Available from: https://ilcor.org/documents/continuous-evidence-evaluation-guidance-and-templates [last accessed 24th August 2020].
15. Ouzzani M., Hammady H., Fedorowicz Z., Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. *Syst Rev.* 2016;5:210.
16. Murad M.H., Sultan S., Haffar S., Bazerbachi F. Methodological quality and synthesis of case series and case reports. *BMJ Evid Based Med.* 2018;23:60-3.
17. Sterne J.A., Hernan M.A., Reeves B.C., Savovic J., Berkman N.D., Viswanathan M., et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ*. 2016;355:i4919.
18. Guyatt G.H., Oxman A.D., Vist G.E., Kunz R., Falck-Ytter Y., Alonso-Coello P., et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ*. 2008;336:924-6.
19. Caldwell G., Millar G., Quinn E. Simple mechanical methods for cardioversion: Defence of the precordial thump and cough version. *Br Med J (Clin Res Ed).* 1985;291:627-30.
20. Petelenz T., Iwinski J., Chlebowczyk J., Czyz Z., Flak Z., Fiutowski L., et al. Self--administered cough cardiopulmonary resuscitation (c-CPR) in patients threatened by MAS events of cardiovascular origin. *Wiad Lek.* 1998;51:326-36.
21. Marozsán I., Albared J.L., Szatmáry L.J. Life-threatening arrhythmias stopped by cough. *Cor Vasa.* 1990;32:401-8.
22. Klumbies A., Paliege R., Volkmann H. Mechanical emergency stimulation in asystole and extreme bradycardia. *Z Gesamte Inn Med*. 1988;43:348-52.

23. Scherf D., Bornemann C. Thumping of the precordium in ventricular standstill. *Am J Cardiol.* 1960;5:30-40.
24. Iseri L.T., Allen B.J., Baron K., Brodsky M.A. Fist pacing, a forgotten procedure in bradyasystolic cardiac arrest. *Am Heart J.* 1987;113:1545-50.
25. Paliege R., Volkmann H., Klumbies A. The first as pace maker for the heart. Investigations about mechanical emergency pacing of the heart. *Deut Gesundheitswes.* 1982;37:1094-100.
26. Nehme Z., Andrew E., Bernard S.A., Smith K. Treatment of monitored out-of-hospital ventricular fibrillation and pulseless ventricular tachycardia utilising the precordial thump. *Resuscitation.* 2013;84:1691-6.
27. Pellis T., Kette F., Lovisa D., Franceschino E., Magagnin L., Mercante W.P., et al. Utility of pre-cordial thump for treatment of out of hospital cardiac arrest: a prospective study. *Resuscitation.* 2009;80:17-23.
28. Gertsch M., Hottinger S., Hess T. Serial chest thumps for the treatment of ventricular tachycardia in patients with coronary artery disease. *Clin Cardiol.* 1992;15:181-8.
29. Rajagopalan R.S., Appu K.S., Sultan S.K., Jagannadhan T.G., Nityanandan K., Sethuraman S. Precordial thump in ventricular tachycardia. *J Assoc Physicians India*. 1971;19:725-9.
30. Miller J., Tresch D., Horwitz L., Thompson B.M., Aprahamian C., Darin J.C. The precordial thump. *Ann Emerg Med*. 1984;13:791-4.
31. Haman L., Parizek P., Vojacek J. Precordial thump efficacy in termination of induced ventricular arrhythmias. *Resuscitation*. 2009;80:14-6.
32. Amir O., Schliamser J.E., Nemer S., Arie M. Ineffectiveness of precordial thump for cardioversion of malignant ventricular tachyarrhythmias. *Pacing Clin Electrophysiol*. 2007;30:153-6.
33. Nejima J. Clinical features and treatment of ventricular tachycardia associated with acute myocardial infarction. *Nihon Ika Daigaku Zasshi.* 1991;58:40-9.
34. Volkmann H., Klumbies A., Kuhnert H., Paliege R., Dannberg G., Siegert K. Terminating ventricular tachycardias by mechanical cardiac pacing by means of precordial thumps. *Z Kardiologie.* 1990;79:717-24.
35. Miller J., Addas A., Akhtar M. Electrophysiology studies: Precordial thumping patients paced into ventricular tachycardia. *J Emerg Med*. 1985;3:175-9.
36. Cotoi S., Moldovan D., Carasca E. Precordial thump in the treatment of cardiac arrhythmias (electrophysiologic considerations). *Physiologie.* 1980;17:285-8.
37. Morgera T., Baldi N., Chersevani D., Medugno G., Camerini F. Chest thump and ventricular tachycardia. *Pacing Clin Electrophysiol.* 1979;2:69-75.
38. Befeler B. Mechanical stimulation of the heart. Its therapeutic value in tachyarrhythmias. *Chest.* 1978;73:832-8.
39. Rahner E., Zeh E. Regulation of ventricular tachycardia with precordial fist blow. *Med Welt.* 1978;29:1659-63.
40. Pennington J.E., Taylor J., Lown B. Chest thump for reverting ventricular tachycardia. *N Engl J Med.* 1970;283:1192-5.
41. Olasveengen T.M., Mancini M.E., Perkins G.D., et al. Adult Basic Life Support: International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Resuscitation* 2020;156:A35-a79.

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