Evidence Review for the Australian and New Zealand Committee on Resuscitation Guidelines

Precordial thump

September 2017

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Abbreviations

ACLS	advanced cardiac life support
AHA	American Heart Association
ALS	advanced life support
AMI	acute myocardial infarction
ANZCOR	Australian and New Zealand Committee on Resuscitation
ARC	Australian Resuscitation Council
AV	atrioventricular
BLS	basic life support
CA	cardiac arrest
CCU	critical care unit
CDSR	Cochrane Database of Systematic Reviews
CENTRAL	Cochrane Central Register of Controlled Trials
CI	confidence interval
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CoS	Consensus on Science
CoSTR	International Consensus on Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC) Science With Treatment Recommendations
CPG	clinical practice guideline
CPR	cardiopulmonary resuscitation
DARE	Database of Abstracts of Reviews of Effects
ECC	Emergency Cardiovascular Care
EED	NHS Economic Evaluation Database
EMS	emergency medical service
EP	electrophysiology
ERC	European Resuscitation Council
GRADE	Grading of Recommendations, Assessment, Development and Evaluation
HTA	Health Technology Assessment
ICD	implantable cardioverter defibrillator
ILCOR	International Liaison Committee on Resuscitation
IQR	interquartile range
JBI	Joanna Briggs Institute
LOE	level of evidence
N/A	not applicable
NHMRC	National Health and Medical Research Council
NR	not reported
OH	out-of-hospital
OHCA	out-of-hospital cardiac arrest
OR	odds ratio
PEA	pulseless electrical activity
PICO	Population, Intervention, Comparator, Outcome
PT	precordial thump
RCT	randomised controlled trial
RE	risk estimate
ROSC	return of spontaneous circulation
RR	relative risk
RVS	right ventricular stimulation
SC	standard care
SCD	sudden cardiac death
SIGN	Scottish Intercollegiate Guidelines Network
SR	systematic review
SV	supraventricular
VA	ventricular arrhythmia
VACAR	Victorian Ambulance Cardiac Arrest Registry
VF	ventricular fibrillation
V-flutter	ventricular flutter
VT	ventricular tachycardia

1 Background

This Technical Report describes a systematic Evidence Review of the published literature investigating the effectiveness of precordial thump (PT) for cardiac arrest, and was conducted for the Australian Resuscitation Council (ARC) to support recommendations for an updated version of the Australian and New Zealand Committee on Resuscitation (ANZCOR) guideline for PT (ANZCOR 2011 Guideline 11.3, Precordial thump and fist pacing).

1.1 BACKGROUND

The Australian and New Zealand Committee on Resuscitation (ANZCOR), as part of the International Liaison Committee on Resuscitation (ILCOR), reviews resuscitation science, summarising findings in consensus statements and treatment recommendations. These Consensus on Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC) Science with Treatment Recommendations (CoSTR) documents are then also used by ILCOR member organisations to generate National guidelines.

In 2015 ILCOR changed from a 5-year cycle of CoSTR development, based on evidence evaluation conducted by ILCOR members and reported in worksheets, to a continuous process for systematic review using Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methodology.

The current ANZCOR guideline for PT was released in July 2011 and included evidence based on the 2010 ILCOR CoSTR. PT has not subsequently been reviewed by ILCOR. ANZCOR have applied current ILCOR review methods to update the ANZCOR PT guideline document.

1.2 CURRENT RECOMMENDATIONS FOR PT

The recommendations regarding PT contained in the 2010 CoSTR are shown in Table 1.1, along with the recommendations contained in the guidelines developed by ANZCOR, the ERC and the AHA (the AHA Integrated Guidelines recommendations are also shown). Recommendations are made for patients with ventricular tachycardia (VT), ventricular fibrillation (VF), asystole, or for shockable rhythms (i.e. VT or VF). The witness status of cardiac arrest is sometimes specified, as is the location of arrest (in-hospital, out-of-hospital).

Table 1.1 Current treatment recommendations for PT

Ref ID Journal	Section	Treatment recommendation from 2010 ILCOR CoSTR
CoSTR		
ILCOR CoSTR 2010 Koster 2010 *Resuscitation*	**Part 5: Adult basic life support** Section: Chest compressions; Alternative compression techniques	The precordial thump is relatively† ineffective for VF, and it should not be used for unwitnessed OHCA. The precordial thump may be considered for patients with monitored, unstable VT if a defibrillator is not immediately available. There is insufficient evidence to recommend for or against the use of the precordial thump for witnessed onset of asystole caused by atrioventricular conduction disturbance.

Ref ID Journal	Section	Treatment recommendation from 2010 ILCOR CoSTR
Guidelines		
ANZCOR Guideline 11.3 July 2011	Available online at https://resus.org.au/guidelines/	The precordial thump may be considered for patients with monitored, pulseless ventricular tachycardia if a defibrillator is not immediately available. [Class B; LOE IV]. The precordial thump is relatively ineffective for ventricular fibrillation, and it is no longer recommended for this rhythm (Koster 2010). There is insufficient evidence to recommend for or against the use of the precordial thump for witnessed onset of asystole caused by AV-conduction disturbance (Koster 2010). The precordial thump should not be used for unwitnessed cardiac arrest (Koster 2010). A precordial thump should not be used in patients with a recent sternotomy (e.g. for coronary artery grafts or valve replacement), or recent chest trauma.

† The word 'relatively' does not appear in the American Heart Association journal, *Circulation*, version of the 2010 ILCOR CoSTR
Abbreviations: AHA, American Heart Association; ALS, advanced life support; ANZCOR, Australian and New Zealand Committee on Resuscitation; AV, atrioventricular ; CoSTR, International Consensus on Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC) Science With Treatment Recommendations; CPR, cardiopulmonary resuscitation; ILCOR, International Liaison Committee on Resuscitation; LOE, level of evidence; OHCA, out-of-hospital cardiac arrest; PT, precordial thump; VF, ventricular fibrillation; VT, ventricular tachycardia.
Note: Text in square brackets inserted by author of current Review.

2 Review methodology

This section of the report describes the methodology used to identify and review the clinical evidence for PT; the research questions, the PICO criteria used to guide the selection of eligible studies, the methodology used to search the published literature and the results of screening that literature.

The approach used to evaluate the body of evidence using the methodology developed by the GRADE Working Group is also described. Based on this evidence, scientific statements and recommendations will be formulated by the ARC Adult Advanced Life Support (ALS) Subcommittee for the updated version of the ANZCOR Guideline for PT.

2.1 RESEARCH QUESTIONS FOR THE CLINICAL EVIDENCE REVIEW

The primary research question was developed by the Adult ALS Subcommittee to focus the systematic review of the literature for PT:

> *Primary question: In patients experiencing cardiac arrest in any setting, does the use of a precordial thump in addition to standard care, compared to standard care, improve short-term (return of spontaneous circulation (ROSC), survival to hospital) or long-term survival (survival to hospital discharge, neurologically intact survival)?*

A supplementary question was developed to capture relevant information from patients who developed arrhythmias during electrophysiology (EP) studies and received PT. As these patients were not necessarily in cardiac arrest, the population and outcomes differ from those in the primary question:

> *Supplementary question: What is the effectiveness of early application of precordial thump in patients experiencing induced arrhythmia, in re-establishing normal cardiac rhythm?*

2.2 PICO CRITERIA

PICO criteria were derived from each of the research questions, using information from the literature and clinical advice from members of the Adult ALS Subcommittee. In addition, any adverse events reported in the included studies were also extracted, to allow an evaluation that balances benefits with potential harms.

As shown in Table 2.1 and Table 2.2, the PICO criteria define the following four elements in detail:

- the target population for the intervention
- the intervention being considered
- the appropriate comparator
- the outcomes that are most relevant to assess safety and effectiveness.

These criteria were applied when screening records for the Review.

Table 2.1 PICO criteria for the primary question for precordial thump

Population	Intervention	Comparator	Outcomes
Patients experiencing cardiac arrest in any setting, with any cardiac rhythm (e.g. VT, VF, PEA, asystole)	Precordial thump (PT) plus standard care	Standard care (e.g. defibrillation with BLS/ALS interventions)	• ROSC (overall and after first manoeuvre) • survival to hospital • survival to hospital discharge • neurologically intact survival • adverse events (e.g. rhythm deterioration) extracted from included studies only

Abbreviations: ALS, ALS, advanced life support; BLS, basic life support; PEA, pulseless electrical activity; PICO, Population, Intervention, Comparator, Outcome; PT, precordial thump; ROSC, return of spontaneous circulation; VF, ventricular fibrillation; VT, ventricular tachycardia.

Table 2.2 PICO criteria for the supplementary question for precordial thump

Population	Intervention	Comparator	Outcomes
Patients experiencing induced arrhythmia while undergoing an electrophysiological investigation.[a]	Early application of precordial thump (PT)	Not applicable	• proportion of patients not requiring other cardioversion methods[b] to re-establish normal cardiac rhythm • proportion of patients converted to other arrhythmia.

a For example, electrophysiological studies; threshold testing during ICD implantation.
b For example, defibrillation, anti-arrhythmia medication.
Abbreviations: ICD, implantable cardioversion defibrillator; PICO, Population, Intervention, Comparator, Outcome.

Studies were excluded for the primary question if patients had arrhythmias but were not in cardiac arrest, or had cardiac arrest induced for an electrophysiology study. Where the cardiac arrest status of patients was unclear, studies were not included in the Review. These studies were eligible for inclusion for the supplementary question.

Results were reported by cardiac rhythm, where available, and by witness status (witnessed or monitored by emergency medical services personnel). Outcomes were ranked according to their level of importance. The GRADE Handbook recommends categorising outcomes as either critical, important, or of limited importance. The methodology implemented by ILCOR for the 2015 CoSTR rank each outcome from 1 to 9, and assigns those with scores of 7 to 9 as critical, 4 to 6 as important, and 1 to 3 as of limited importance. According to the GRADE methodology, critical and important outcomes are those that will bear on guideline recommendations, while in most situations those of limited importance will not. Table 2.3 shows the PICO outcomes along with the scores and levels of importance attributed to these outcomes.

Table 2.3 Ranking of PICO outcomes

Outcome	Score	Level
ROSC after first manoeuvre	6	Important
Overall ROSC	9	Critical
Survival to hospital	9	Critical
Survival to hospital discharge	9	Critical
Neurologically intact survival	9	Critical
Termination of arrhythmia	6	Important
Rhythm deterioration	3	Important

Abbreviations: PICO, Population, Intervention, Comparator, Outcome; ROSC, return of spontaneous circulation.

2.3 SYSTEMATIC LITERATURE REVIEW OF CLINICAL EVIDENCE

A comprehensive search of peer-reviewed scientific literature was conducted for original publications of individual studies, health technology assessments (HTAs) or systematic reviews providing clinical evidence

of the effectiveness of PT. The following electronic databases were searched: Embase, Medline and CINAHL, and the Cochrane Library databases shown in Table 2.4. A search of the grey literature was not undertaken; however, the reference lists of included studies were scanned for additional studies not identified in the formal literature search.

Table 2.4 Databases searched for the Evidence Review of precordial thump

Database	Search date, Australia	Search period
Embase (OVID)	26 April 2017	not limited
Medline (OVID)	26 April 2017	not limited
CINAHL (EBSCO Host)	26 April 2017	not limited
The Cochrane Library: • Cochrane Database of Systematic Reviews (CDSR) • Cochrane Central Register of Controlled Trials (CENTRAL) • Database of Abstracts of Reviews of Effects (DARE) • Health Technology Assessment Database (HTA) • NHS Economic Evaluation Database (EED).	21 April 2017	not limited

Abbreviations: CINAHL, Cumulative Index to Nursing and Allied Health Literature.

2.3.1 Literature search strategy

A single literature search was performed to capture records relevant to both the primary and supplementary questions. The search strategies used for each database and the resulting number of identified records are shown in Table 2.5.

Table 2.5 Search strategies used to identify studies of precordial thump: Embase, Medline, CINAHL and the Cochrane Library

#	Database and search terms	Records
Embase Classic + Embase 1947 to 2017 April 25 Searched on OVID 26 Apr 2017		
1	((precordial or precordium) and (thump$ or blow$)).mp.	**145**
2	(chest thump or chest blow or thumpversion).mp.	**51**
3	exp resuscitation/ or resuscitation.mp.	**120,332**
4	exp heart arrest/	**72,433**
5	(out of hospital and cardiac arrest).mp.	**8,645**
6	exp "out of hospital cardiac arrest"/	**5,497**
7	(cardiopulmonary resuscitation or cardiac arrest).mp.	**51,487**
8	3 or 4 or 5 or 6 or 7	**171,487**
9	8 and thump$.mp.	**164**
10	1 or 2 or 9	**285**
OVID MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, OVID MEDLINE(R) Daily and OVID MEDLINE(R) 1946 to Present Searched on OVID 26 Apr 2017		
1	((precordial or precordium) and (thump$ or blow$)).mp.	**107**
2	(chest thump or chest blow or thumpversion).mp.	**45**
3	exp Resuscitation/ or exp Cardiopulmonary Resuscitation/	**84187**
4	resuscitation.mp.	**63991**
5	exp Heart Arrest/	**41475**
6	exp Out-of-Hospital Cardiac Arrest/	**2300**
7	(Out of Hospital and Cardiac Arrest).mp.	**5270**
8	(cardiopulmonary resuscitation or cardiac arrest).mp.	**39237**
9	3 or 4 or 5 or 6 or 7 or 8	**141421**
10	9 and thump$.mp.	**141**
11	1 or 2 or 10	**214**

#	Database and search terms	Records
CINAHL		
Searched on EBSCO host 26 April 2017		
S1	(precordial or precordium) and (thump* or blow*)	**20**
S2	(chest thump) or (chest blow) or thumpversion	**21**
S3	(MH "Resuscitation+") OR "resuscitation" OR (MH "Resuscitation, Cardiopulmonary+") OR (MH "Bystander CPR")	**28,468**
S4	resuscitation	**17,299**
S5	(MH "Heart Arrest+") OR "heart arrest"	**9,523**
S6	(heart or cardiac) arrest	**8,701**
S7	S3 OR S4 OR S5 OR S6	**35,614**
S8	S7 and thump*	**13**
S9	S1 OR S2 OR S8	**36**
S10	S9 - exclude Medline records	**4**
Cochrane Library of Databases: CDSR; CENTRAL; DARE; HTA; EED		
Searched 21 April 2017		
#1	precordial and (thump or blow)	**1**
#2	chest and (thump or blow)	**23**
#3	MeSH descriptor: [Heart Arrest] explode all trees	**1,487**
#4	(cardiac arrest) or (cardiopulmonary resuscitation)	**3,768**
#5	MeSH descriptor: [Resuscitation] explode all trees	**4,439**
#6	(precordial or thump or blow) and (#3 or #4 or #5)	**21**
#7	thumpversion	**0**
#8	"#1 or #2 or #6 *Limited to Cochrane Reviews (Reviews and Protocols), Other Reviews, Trials, Technology Assessments and Economic Evaluations"*	**40**
	Cochrane Reviews	*24*
	Other reviews	*2*
	Trials	*12*
	Technology assessments	*0*
	Economic evaluations	*2*

Abbreviations: CDSR, Cochrane Database of Systematic Reviews; CENTRAL, Cochrane Central Register of Controlled Trials; CINAHL, Cumulative Index to Nursing and Allied Health Literature; DARE, Database of Abstracts of Reviews of Effects; HTA, Health Technology Assessment; EED, NHS Economic Evaluation Database.
Note: OVID fields searched with mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms.

2.3.2 Eligibility criteria

The inclusion and exclusion criteria for identifying relevant studies are shown for the primary question (Table 2.6) and the supplementary question (Table 2.7). Published studies, HTAs and clinical trials were eligible for inclusion, but not conference abstracts etc. Population, intervention and outcome eligibility were as defined in the PICO for each question (no comparator restrictions were imposed during the eligibility screening).

Eligible study designs ranged from randomised controlled trials (RCTs) to consecutive case series (case reports and collections of case reports were excluded). While not eligible for inclusion in the body of evidence, systematic reviews were to be summarised and included studies checked for eligibility for this Review. No language or publication date restrictions were applied.

Table 2.6 Screening inclusion and exclusion criteria for primary question

Category	Inclusion criteria	Exclusion criteria
Publication type	Published journal articles, health technology assessments and clinical trials.	Conference abstracts, letters and editorials, opinion pieces and commentaries, informal or non-systematic reviews.
Population	As per PICO criteria: patients experiencing cardiac arrest in any setting, with any cardiac rhythm.	Patients not in cardiac arrest, in electro-physiologically induced cardiac arrest, or of unclear cardiac arrest status.
	Studies in humans.	Studies in animals or in-vitro studies.

Category	Inclusion criteria	Exclusion criteria
Intervention	As per PICO criteria: PT plus standard care.	PT applied repetitively (pacing).
Outcomes	As per PICO criteria: ROSC (overall and after first manoeuvre); survival to hospital; survival to hospital discharge; neurologically intact survival; adverse events (e.g. rhythm deterioration).	–
Study design	RCTs, quasi-randomised studies, non-randomised comparative studies, controlled cohort studies, single cohort studies, consecutive case series. Identified relevant systematic reviews were to be briefly summarised and checked for included individual studies.[1]	Case reports, non-consecutive case series.
Study language	No language restrictions if abstract available in English.	Studies without an English abstract.
Publication date	No publication date restrictions.	–

Abbreviations: PICO, Population, Intervention, Comparator, Outcome; PT, precordial thump; RCT, randomised controlled trial

Table 2.7 Screening inclusion and exclusion criteria for supplementary question

Category	Inclusion criteria	Exclusion criteria
Publication type	Published journal articles, health technology assessments and clinical trials.	Conference abstracts, letters and editorials, opinion pieces and commentaries.
Population	As per PICO criteria: experiencing any arrhythmia while undergoing electrophysiological investigations, with or without cardiac arrest. Studies in humans.	Patients not in cardiac arrest, in electro-physiologically induced cardiac arrest, or of unclear cardiac arrest status. Studies in animals or in-vitro studies.
Intervention	As per PICO criteria: PT.	PT applied repetitively (pacing).
Outcomes	As per PICO criteria: immediate termination of arrhythmia; immediate change to other rhythm; no rhythm change.	–
Study design	RCTs, quasi-randomised studies, non-randomised comparative studies, controlled cohort studies, single cohort studies, consecutive case series. Identified relevant systematic reviews were to be briefly summarised and checked for included individual studies.[2]	Case reports, non-consecutive case series, non-systematic reviews.
Study language	No language restrictions if abstract available in English.	Studies without an English abstract.
Publication date	No publication date restrictions.	–

Abbreviations: PICO, Population, Intervention, Comparator, Outcome; PT, precordial thump; RCT, randomised controlled trial.

2.3.3 Screening of records from literature search

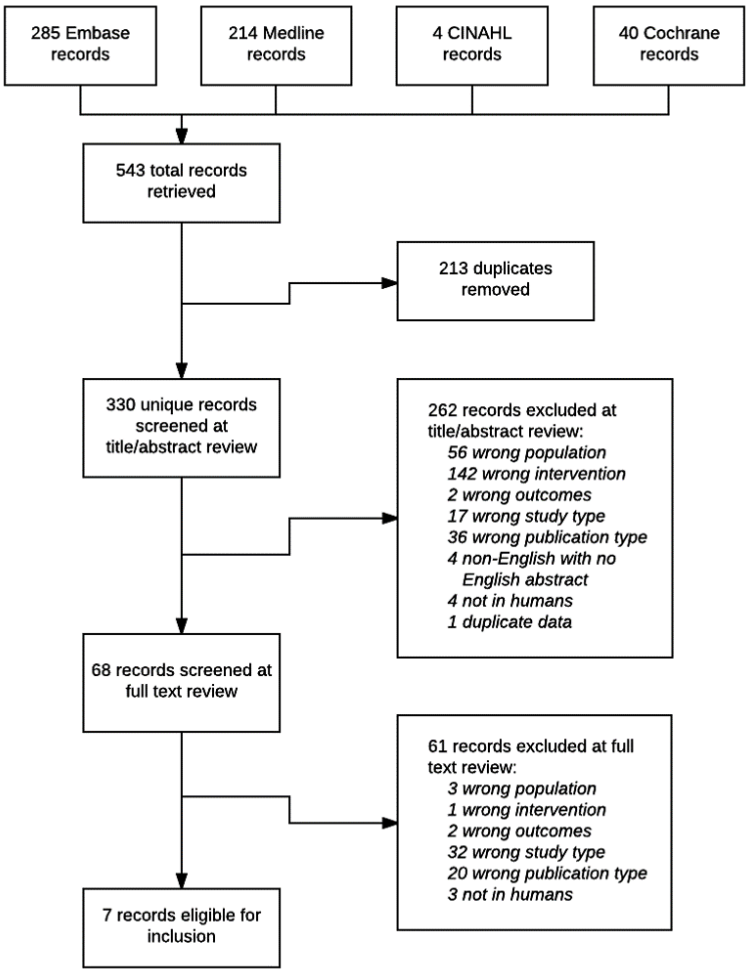
A total of 543 records were identified in the literature search across all databases, of which 330 were unique. These records were screened by two reviewers – a methodologist and a clinical expert – using the eligibility criteria described above in Section 2.3.2. Any discrepancies in exclusion were resolved by discussions between the two reviewers.[3]

The results of this screening are shown in Figure 2.1 (and by database in Appendix A). At title/abstract review, 262 records were excluded, and a further 61 were excluded at full text review (see Appendix B, Table AppB.1 for reasons for exclusion of studies at full text review). Three studies were excluded based on presumptions regarding study design without reference to the full text. These are listed in Appendix A (Table AppB.2).

Seven studies were identified as eligible for inclusion in this Evidence Review, three for the primary question and four for the supplementary question.

[1] No systematic reviews were identified.
[2] No systematic reviews were identified.
[3] The two reviewers were in concordance regarding study inclusion/exclusion.

Figure 2.1 PRISMA diagram showing the results of exclusion criteria application during screening



Abbreviations: CINAHL, Cumulative Index to Nursing and Allied Health Literature.

2.4 Assessment of eligible studies for inclusion in the Review

2.4.1 Hierarchy of study design

From the identified eligible studies, those to be included in the Review were selected by establishing the highest level of evidence available for each population and outcome in the PICO. Eligible studies were classified according to the study designs shown in Table 2.8. This classification is based on the National Health and Medical Research Council (NHMRC) Evidence Hierarchy (see Appendix C), with minor clarifications for Level IV studies (discussed in detail in Section 2.4.3).

Table 2.8 Hierarchy of study design used to rank eligible studies for inclusion

Level	Study design
II	Randomised controlled trials
III-1	Quasi-randomised controlled trials
III-2	Non-randomised experimental trial, and cohort or case-control studies, with concurrent control group
III-3	Cohort or case-control studies, with historical control group
IV	Single group of exposed patients only: • single cohort studies, including case series of consecutive patients deemed to be representative of the patient population • case series deemed not necessarily representative of the patient population

Based on the NHMRC Evidence Hierarchy, NHMRC levels of evidence and grades for recommendations for developers of guidelines. Canberra: National Health and Medical Research Council, 2009.

Where evidence from one level is available for a particular PICO outcome, studies of a lower level reporting the same outcome would be excluded for that outcome. Conversely, if higher level studies do not report a particular PICO outcome, lower level evidence can be included for that outcome. These hierarchy rules were also applied to any PICO population subgroups, such as cardiac arrhythmia or setting (out-of-hospital; in hospital).

This process was performed separately for the primary and supplementary questions. Classification of the levels of evidence of the included studies is reported in the Results section of this Review (Section 3.2).

2.4.2 Uncontrolled studies when control rates are near zero

The quality of evidence from uncontrolled studies is usually considered to be very low. However, where outcome rates in the absence of the intervention are known to be close to zero, non-comparative studies of a single group of exposed patients can provide high quality evidence. In the area of resuscitation, the time between intervention and outcome assessment is frequently very short, and interventions are frequently applied in a stepwise manner dependent on the relatively immediate response of the patient. Consequently, single-group studies can often yield useful pre-test/post-test style information in the resuscitation field, despite the lack of a control group.

The NHMRC Evidence Hierarchy (Appendix C) includes only a single study type for non-comparative studies: case series with either post-test or pre-test/post-test outcomes. However, in light of the variety of quality encompassed in this single classification, it was decided to make a distinction between studies in this category based on the perceived representativeness of the patient sample. The rationale for this adaptation is described below.

2.4.3 Cohort studies and case series definitions

Single cohort studies may be regarded as providing higher quality evidence than case series, based on the reasoning that they are typically larger and therefore more representative of the patient population. However, the difference between a single cohort study and case series of exposed patients is not well defined, as they both select patients based on having been exposed to an intervention[4]. In fact, as described above, the NHMRC Evidence Hierarchy does not distinguish between single cohort studies and case series, with all being classifiable as Level IV.

While sample size is typically used to distinguish between single cohort studies and case series, such an approach requires an arbitrary threshold of patient numbers to distinguish one study type from the other. The degree to which a study group is thought to be representative of the patient population is impacted, however, by other factors in addition to sample size. For example, a smaller study with consecutive patients, with any exclusions clearly reported, can be more representative than a larger study with ill-defined inclusion/exclusion criteria or no statement regarding the completeness of the cohort.

For the purpose of this Evidence Review, where the patient sample is considered likely to be representative of the patient population, a case series is classified as a single cohort study, while an incomplete or poorly described series of patients will be referred to as case series. As described in Section 2.4.1 above, these two study types are classified on different levels in this Review.

[4] It has been proposed by various authors (Dekkers et al 2014; Esene et al 2014; Mathes and Pieper 2017) that the term case series should be reserved for studies that sample patients based on outcome (i.e. all patients in the study have a particular manifestation of an outcome), and studies of patients with the same exposure should be referred to as single cohort studies. However, such a restrictive definition is potentially confusing given the popular use of the term ‘case series’ for studies of patients with the same exposure to an intervention. Furthermore, it does not make a distinction between consecutive case series that may be representative, and non-consecutive case series that are unlikely to be so.

2.5 CONCORDANCE WITH EVIDENCE BASE OF PRIOR ILCOR COSTR

In the ILCOR CoSTR publications, statements regarding clinical findings are associated with study citations, making it possible to identify the body of evidence on which recommendations are based. Due to potential differences in eligibility criteria, studies included in prior ILCOR CoSTRs may not be included in the current Review, and studies published after the prior ILCOR CoSTRs literature reviews may appear in the current Review. Studies included in the prior ILCOR CoSTR for PT were identified to assess concordance with the body of evidence for the current Review (Section 3.3).

2.6 CHARACTERISTICS OF INCLUDED STUDIES

An overview of the study characteristics is provided, with a study characteristics table and a narrative summary describing the salient features of study design. Details of the population, intervention, comparator and outcome measures are summarised for each study, and, where applicable, any relevant statistical methodology is also described. In the current Review, this information is reported in Section 3.4.

2.7 RISK OF BIAS OF INDIVIDUAL STUDIES

The risk of bias associated with each included study was assessed using a checklist appropriate for the study design (Table 2.9). Where possible, a checklist from the Scottish Intercollegiate Guidelines Network (SIGN) collection was used. The lowest level of evidence for which a risk-of-bias tool is available from this resource is comparative cohort studies – lower levels of evidence (single cohort studies and consecutive case series) were assessed using the Critical Appraisal Tool for Case Series developed by The Joanna Briggs Institute.

Table 2.9 Critical appraisal tools for specific study designs

Level	Study design	Critical appraisal tool	
II/III-1	RCT/ quasi-randomised controlled trials	SIGN	Methodology Checklist 2 for RCTs
III-2/III-3	Non-randomised experimental trials, cohort studies with control group (concurrent or historical)	SIGN	Methodology Checklist 3 for Cohort Studies
III-2	Case-control studies	SIGN	Methodology Checklist 4 for Case-control Studies
IV	Single cohort/representative case series	JBI	Critical Appraisal Checklist for Case Series
IV	Non-representative case series	NA	

Abbreviations: JBI, Joanna Briggs Institute; NA, not applicable; RCT, randomised controlled trial; SIGN, Scottish Intercollegiate Guidelines Network.

All checklists were adapted by making note of the following:

- differential risk of bias across outcomes within a study, where present
- the source of funding and any noted conflicts of interest for the authors.

The risk-of-bias assessments of studies included in the current Review are shown in Section 3.5.

2.8 GRADING THE BODY OF EVIDENCE FOR EACH OUTCOME

2.8.1 Identify data for inclusion in the body of evidence

Prior to creating evidence profile tables, the evidence extracted for each outcome from the included studies was reviewed for inclusion in the body of evidence. Data may be excluded from the body of evidence if it is derived from a population that is indirectly related to the relevant population but there is sufficient direct evidence. Similarly, where a substantial quality gap exists between the majority of the data and the remaining data for an outcome, the lower quality data may be excluded from the body of evidence for that outcome.

2.8.2 Establish level of quality based on study design

For intervention studies, RCTs are rated as high quality prior to downgrading for any risk of bias, while the highest level that can be allocated to observational studies is low. Any downgrading of quality may be applied according to the guidelines described in the following section.

2.8.3 Assess any limitations in each of five domains

The quality of the body of evidence could be downgraded for one or more of the five domains examined in GRADE: risk of bias, inconsistency, indirectness, imprecision, and publication bias. The following general rules were used to assess the body of the evidence:

- Downgrading by one or two levels for risk of bias could be undertaken depending on the degree to which any risk of bias in individual studies impacted on the overall risk of the body of evidence.
- The quality of the evidence was downgraded one level for inconsistency where there was moderate heterogeneity within a meta-analysis (I^2 between 25% and 59%). The certainty of the evidence was downgraded two levels for inconsistency where there was substantial heterogeneity within a meta-analysis ($I^2 \geq 60\%$).
- The quality of the evidence was downgraded one level for indirectness where surrogate outcomes are used, or where there was a difference between the population (or intervention) of interest and the study population (or intervention). Indirect comparisons of groups from different studies are usually downgraded at least one level, as they are subject to limitations regarding the degree of similarity between the trials in question.
- The quality of the evidence was downgraded one level for imprecision where the 95% confidence interval (CI) of the relative risk (RR) crossed 1.00, and where either the lower limit crossed 0.75 or the upper limit crossed 1.25; this indicates the true effect may include a measure of appreciable benefit and/or harm.
- The certainty of the evidence could be downgraded due to publication bias where detected or strongly suspected.

2.8.4 Assign overall quality of the body of evidence for each outcome

After assigning quality to each of the five domains described above, the overall quality of the body of evidence can be ascertained. The definitions of the four levels of quality are shown in Table 2.10. These levels of quality are indicated graphically with a symbol in the evidence profile tables.

Table 2.10 Quality of evidence grades defined in the GRADE Handbook

Grade	Symbol	Definition
High	●●●●	We are very confident that the true effect lies close to that of the estimate of the effect.
Moderate	●●●○	We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low	●●○○	Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect.
Very Low	●○○○	We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect.

Source: GRADE Handbook, Schünemann 2013, Table 5.1 (accessed online 24 July 2017).
Abbreviations: GRADE, Grading of Recommendations, Assessment, Development and Evaluation.

2.8.5 Evidence profile tables

For each patient population, an evidence profile table was created, presenting the following characteristics of the body of evidence for each outcome:

- Number and reference IDs of included studies
- Study design

- Presence of any serious limitations in each of the following five domains:
    - Risk of bias from study design and reporting limitations
    - Inconsistency of findings across included studies
    - Indirectness of studies with regard to the clinical question
    - Imprecision of estimate of effect
    - Publication bias
- Event rates for both groups, expressed as n/N (%)
- Effect of the intervention expressed as RR [95% CI]
- Assumed risk per 1,000 events
- Absolute risk difference, expressed as number of additional (or fewer) events per 1000 [95% CI].
- Quality level of the body of evidence (high, moderate, low or very low)
- Importance of outcome (critical, important, limited importance).

2.9 Evidence statements

The current methodology for the ILCOR guidelines does not include a summary of findings table as described in the GRADE Handbook (Schünemann 2013). Instead, a written summary of evidence was created for each outcome – an evidence statement – which included the following:

- the level of importance of the outcome (critical, important, limited importance)
- the quality of the body of evidence (high, moderate, low or very low)
- if the quality of evidence was downgraded, the reason for downgrading
- the number of studies in the body of evidence
- the number of included patients in the body of evidence
- the relative benefit/risk of the compared interventions
- the risk estimate with confidence interval
- the absolute change in risk, where statistically significant.

2.10 Synthesis of non-comparative evidence

Non-comparative evidence cannot be assessed using GRADE methodology. However, where prior recommendations have been made on the basis of non-comparative evidence, it may be necessary to include such evidence in future reviews in order to make an assessment regarding the appropriateness of prior Consensus on Science (CoS) statements and allow recommendations to be changed, if necessary, with confidence that all the evidence has been taken into account. Non-comparative evidence was discussed in the results section and a narrative synthesis of findings section includes a discussion of both the comparative and non-comparative evidence.

2.11 Information to assist reconciliation with prior ILCOR Consensus on Science statements

In order to assist in the reconciliation of prior CoS statements with the new findings of Evidence Reviews, prior statements are presented with the cited studies shown by first author and year, along with whether that study is included in the current body of evidence, and relevant details of the studies that may indicate the reason for exclusion in the current Review (e.g. population). In this Review, this information is included in the appendices section.

3 Results

3.1 IDENTIFICATION OF ELIGIBLE STUDIES

The literature search for clinical evidence of the effectiveness of PT identified 330 unique database records. After application of the inclusion/exclusion criteria (Section 2.3.2), three studies relevant to the primary question were eligible for inclusion in the current Review:

- Nehme 2013 – an Australian record review of out-of-hospital cardiac arrest (OHCA) cases from the Victorian Ambulance Cardiac Arrest Registry (VACAR)
- Pellis 2009 – a prospective, Italian study of OHCA cases from the Pordenone operative dispatch centre and emergency medical service (EMS) ambulance network
- Miller 1984 – a retrospective, US study of OHCA cases receiving PT from the Milwaukee County Paramedic System.

A further four studies relevant to the supplementary question were also eligible for inclusion in the current Review:

- Haman 2009 – a prospective, Czech Republic study of sustained non-tolerated ventricular arrhythmia induced during electrophysiological procedures
- Amir 2007 – a prospective, Israeli study of unstable malignant ventricular tachyarrhythmia induced during electrophysiological procedures
- Volkmann 1990 – consecutive cohort in Germany with VT or VF/ventricular flutter
- Miller 1985 – a prospective, US study of sustained VT induced during electrophysiological procedures.

All seven eligible studies were assessed for inclusion in the Review after ascertainment of study design (Section 3.2). A comparison with the evidence base for the prior ILCOR CoSTR is described in Section 3.3, and the study characteristics are summarised in Section 3.4.

3.2 ASSESSMENT OF ELIGIBLE STUDIES FOR INCLUSION IN THE REVIEW

The levels of evidence of the seven included studies is represented in Table 3.1. The three studies relevant to the primary question includes a comparative cohort and single cohort studies. Nehme 2013 is a retrospective study that identified two cohorts: patients who received PT as a first manoeuvre and patients who received defibrillation as a first manoeuvre. The data presented are comparative for these two cohorts. The majority of data reported in Pellis 2009 is from a single prospective cohort that received PT as the first manoeuvre. However, for some outcomes these patients were compared with a cohort that did not receive PT first, making it a comparative study for those outcomes. For this reason, and because it includes a broader population than the Nehme 2013 study with respect to cardiac rhythm, the Pellis 2009 study was also included.

As little evidence is available investigating PT for cardiac arrest, it was decided to include the single cohort Miller 1984 study despite being lower level evidence than the other two studies. For similar reasons, it was decided to extract the non-comparative data from Pellis 2009 in addition to the limited comparative data.

Of the four studies relevant to the supplementary question, three were single cohort studies (consecutive case series) and one was a case series of unclear completeness (Miller 1985). In light of the limited available evidence, it was decided to include the single case series study despite being lower level evidence than the other studies.

Table 3.1 Levels of evidence of studies eligible for inclusion in the Evidence Review of precordial thump

Study ID	RCT	pseudo-RCT	comparative cohort	single cohort	case series
Primary question					
Nehme 2013			✓		
Pellis 2009			✓	✓	
Miller 1984				✓	
Supplementary question					
Haman 2009				✓	
Amir 2007				✓	
Volkmann 1990				✓	
Miller 1985					✓

Abbreviations: RCT, randomised controlled trial.

After assessment of levels of evidence, the seven eligible studies were all included in the current Evidence Review. Full citation details are provided in Table 3.2.

Table 3.2 Full citation details of included studies for the Evience Review of precordial thump

Study ID	Citation
Primary question	
Nehme 2013	Nehme Z, Andrew E, Bernard SA, Smith K. (2013). Treatment of monitored out-of-hospital ventricular fibrillation and pulseless ventricular tachycardia utilising the precordial thump. Resuscitation. 84(12):1691-6.
Pellis 2009	Pellis T, Kette F, Lovisa D, Franceschino E, Magagnin L, Mercante WP, et al. (2009). Utility of pre-cordial thump for treatment of out of hospital cardiac arrest: A prospective study. Resuscitation. 80(1):17-23.
Miller 1984	Miller J, Tresch D, Horwitz L, Thompson BM, Aprahamian C, Darin JC. (1984). The precordial thump. Annals of Emergency Medicine. 13(9 II):791-4.
Supplementary question	
Haman 2009	Haman L, Parizek P, Vojacek J. (2009). Precordial thump efficacy in termination of induced ventricular arrhythmias. Resuscitation. 80(1):14-6.
Amir 2007	Amir O, Schliamser JE, Nemer S, Arie M. (2007). Ineffectiveness of precordial thump for cardioversion of malignant ventricular tachyarrhythmias. PACE - Pacing and Clinical Electrophysiology. 30(2):153-6.
Volkmann 1990	Volkmann H, Klumbies A, Kuhnert H, Paliege R, Dannberg G, Siegert K. (1990). Termination of ventricular tachycardias by mechanical cardiac pacing by means of precordial thumps. [German]. Zeitschrift fur Kardiologie. 79(10):717-24.
Miller 1985	Miller J, Addas A, Akhtar M. (1985). Electrophysiology studies: Precordial thumping patients paced into ventricular tachycardia. Journal of Emergency Medicine. 3(3):175-9.

3.3 CONCORDANCE WITH EVIDENCE BASE OF PRIOR ILCOR COSTR

PT is not included in the most recent ILCOR CoSTR published in 2015, but 13 studies formed the body of evidence for PT in the 2010 ILCOR CoSTR (Table 3.3).[5] Six of these 13 studies are eligible for inclusion in the current Review (Pellis 2009; Miller 1984; Haman 2009, Amir 2007, Volkmann 1990; Miller 1985) and all six were identified in the literature search. The remaining seven studies that formed the body of evidence for PT in the 2010 ILCOR CoSTR did not meet the current eligibility criteria – the reasons for exclusions are shown in Table 3.3.

Table 3.3 Studies included in the 2010 ILCOR CoSTR evidence base for PT (Koster 2010; Sayre 2010)

Study ID	Reason for exclusion from current Evidence Review
Eligible for inclusion in current Review – primary question	
Pellis 2009	Eligible cohort study with comparative cohort for some outcomes
Miller 1984	Eligible single cohort study

[5] This evidence is a subset of all 45 studies identified by the three literature reviews (Worksheets) that were conducted for the 2010 ILCOR CoSTR.

Study ID	Reason for exclusion from current Evidence Review
Eligible for inclusion in current Review – supplementary question	
Haman 2009	Eligible single cohort study
Amir 2007	Eligible single cohort study
Volkmann 1990	Eligible single cohort study
Miller 1985	Eligible case series
Ineligible for current Review due to study design	
Ahmar 2007	Excluded based on study design: case report (this study reported an adverse outcome after PT: sternal fracture and the development of sternal osteomyelitis).
Muller 1992	Excluded based on study design: two isolated case reports.
Caldwell 1985	A mix of precordial thump and cough version were administered but the number of patients receiving each intervention was not reported (i.e. denominator not reported). Also, the patient population was a mixture of CA and non-CA.
Cotol 1980	Excluded based on study design: case reports.
Ineligible for current Review due to population	
Morgera 1979	Not patients undergoing electrophysiology investigations. Patients with VT but CA status not reported in full text article (some with AMI), therefore not necessarily patients in cardiac arrest.
Befeler 1978	Random selection of ward patients and patients undergoing electrophysiology investigations, so excluded based on mixture of eligible and ineligible population. Also, a mix of interventions used, and only 16 patients received PT (i.e. case series for PT).
Not identified in current Review, but ineligible due to population	
Nejima 1991	Not identified in literature search – did not use alternative forms of thumpversion (thump version or thump-version) in search strings. Epidemiological study of patients with VT after AMI[6], so not in cardiac arrest nor undergoing electrophysiology investigations.

Abbreviations: AMI, acute myocardial infarction; CA, cardiac arrest; CCU, critical care unit; CoSTR, International Consensus on Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC) Science with Treatment Recommendations; ICD, implantable cardioverter defibrillator; ILCOR, International Liaison Committee on Resuscitation; PT, precordial thump; VF, ventricular fibrillation; VT, ventricular tachycardia.

One of the studies in the 2010 ILCOR CoSTR evidence base for PT was not identified in the literature search for the current Review (Nejima 1991). This study was not captured, as although the search strings included the term 'thumpversion', they did not include the alternative forms 'thump version' or 'thump-version'. This study would have been excluded for both research questions due to study population. The literature searches were rerun and a further two studies were also identified by the addition of these terms; however, neither were eligible for inclusion in the current Review[7] (nor were they in the 2010 ILCOR CoSTR evidence base for PT).

3.4 CHARACTERISTICS OF INCLUDED STUDIES

Study characteristics are presented separately for the two relevant populations: patients with cardiac arrest (primary question) and patients with an arrhythmia induced during EP investigations (supplementary question).

3.4.1 Overview of study characteristics

Cardiac arrest

The characteristics of the included studies of patients in CA are summarised in Table 3.4.

Nehme 2013 is an Australian record review of OHCA cases from the Victorian Ambulance Cardiac Arrest Registry (VACAR) from 2003 to 2011, comparing 103 patients that received PT with 325 patients that received defibrillation as the first resuscitative manoeuvre. Patients who suffered a monitored cardiac

[6] Full text not retrieved but information taken from 2010 ILCOR Worksheets for precordial thump.

[7] A study of patients with acute myocardial infarction i.e. not necessarily a cardiac arrest population and not an electrophysiology study (Hayakawa 1985) and a letter to the editor (Kostis and Goodkind 1972), neither of which were part of the 2010 ILCOR PT evidence base.

arrest with pulseless VT or VF, either as a rhythm occurring during presentation (presenting rhythm) or developing during resuscitation, were eligible for inclusion in the study.

Pellis 2009 is a prospective, Italian study of OHCA cases attended to by the Pordenone operative dispatch centre and EMS ambulance network from March 2004 to November 2005.[8] Study inclusion was not limited by CA witness status nor by cardiac rhythm – all patients in CA for whom it was decided to attempt CPR were eligible. Patients received either the 'PT protocol' (PT as the first resuscitative manoeuvre followed by standard care, n = 144) or standard care (no PT; n = 219). While the study cohort is defined as those patients who received the PT protocol, for limited outcomes they are compared with those who did not receive PT during CPR. The majority of data, however, are from the PT cohort only.

Miller 1984 is a retrospective, US study of 50 OHCA patients who received PT from the Milwaukee County Paramedic System from July 1982 to February 1983. No control group was included in this study. This cohort of pulseless, nonbreathing patients who received PT had monitored VT/VF (either presenting rhythm or developed during resuscitation).

[8] This was part of a larger epidemiological study but no reference to the larger study is provided.

Table 3.4 Characteristics of included studies of PT for patients in cardiac arrest

Study ID	Study design Country, study setting Period	CA setting, witness status Population	Time to PT/defibrillation	Eligible cardiac rhythms	Intervention (PT)	Comparator	Outcomes
Nehme 2013	Retrospective cohort study with control group Australia; Victorian Ambulance Cardiac Arrest Registry (VACAR) 2003–2011	OH, EMS-witnessed Patients >15 years who suffered a monitored VT/VF cardiac arrest out of hospital. Excluded patients with deterioration to non-shockable rhythms prior to either intervention, and patients with non-cardiac aetiology of arrest.	Time to first defibrillation:[9] median 1 min (IQR 0.0, 2.0)	Shockable rhythms: • pulseless VT (referred to hereon as VT) • VF	PT as first manoeuvre, followed by standard care n = 103	Defibrillation as first manoeuvre (standard care, no PT) n = 325	• ROSC after first manoeuvre • Overall ROSC • Survival to hospital discharge • Rhythm change without ROSC after PT • No rhythm change after first manoeuvre
Pellis 2009	Prospective cohort study with control group[10] Italy; Pordenone operative dispatch centre and EMS ambulance network Mar 2004–Nov 2005	OH, EMS-witnessed or unwitnessed (see Table 3.6 for %) All patients in CA (confirmed according to the 2000 ILCOR guidelines) for whom it was decided to attempt CPR.	Time to PT: • witnessed: all treated <3 min[11] • unwitnessed: 9.48 min[12] (IQR 6, 12) range 2-35 min Time to first defibrillation in non-PT cohort: • witnessed: NR • unwitnessed: mean 24 min (IQR 5, 11)[13]	Shockable and unshockable rhythms: • VT[14] • VF • PEA • asystole	PT as first manoeuvre, followed by standard care n = 144	Defibrillation as first manoeuvre (standard care, no PT) n = 219	PT vs non-PT, reported by cohort: • Overall ROSC • Survival to discharge PT cohort only, reported by cardiac rhythm: • ROSC after PT • Rhythm change, no ROSC, after PT • No rhythm change immediately after PT • After post-PT CPR: ○ ROSC ○ rhythm change without ROSC ○ no rhythm change • Overall ROSC • Survival to discharge
Miller 1984	Retrospective single cohort study US; Milwaukee County Paramedic System Jul 1982–Feb 1983	OH, EMS-monitored Patients 41 years to 92 years in CA[15] who developed monitored VT/VF and received PT.	Time to PT or subsequent defibrillation not reported.	• VT • VF	PT as first manoeuvre, followed by standard care N = 50	N/A	• ROSC after PT (supraventricular rhythm with pulse) • Overall ROSC (resuscitation) • Rhythm change after PT, with no ROSC • No change in rhythm after PT

Abbreviations: CA, cardiac arrest; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; ILCOR, International Liaison Committee on Resuscitation; IQR, interquartile range; NR, not reported; OH, out-of-hospital; PEA, pulseless electrical activity; PT, precordial thump; ROSC, return of spontaneous circulation; VF, ventricular fibrillation; VT, ventricular tachycardia.

[9] Time to first PT not reported, but since all cases were witnessed CA, it would be less than time to first defibrillation.
[10] Comparison group used for limited outcomes only.
[11] Not reported for cohort that did not receive PT.
[12] Reported as mean in the text, with both IQR and range, but same results reported in Table 1 of Pellis 2009 with IQR only and no specification of statistical measure, so may be median.
[13] Statistical measure not reported, but likely to be median.
[14] Only a single patient presented with VT across both cohorts: an unwitnessed CA in the PT cohort.
[15] Methods describe population for PT as pulseless non-breathing patients in VF or VT.

Induced arrhythmia

The characteristics of the included studies of patients with arrhythmias induced during EP investigations are shown in Table 3.5.

The Haman 2009 prospective study was conducted in the Czech Republic over a six-year period from May 2001. It reports the use of PT in 155 consecutive patients undergoing EP investigations for sudden cardiac death (SCD) prevention who experienced induced, non-tolerated VT or VF.

The prospective study described in Amir 2007 included 80 consecutive patients experiencing VT or VF while undergoing either EP studies or ICD implant testing at the Technion-Israel Institute of Technology, Haifa, Israel. Patients with sternal instability were excluded from the study.

Volkmann 1990 is a prospective study conducted in a cardiology clinic in Germany, investigating 47 ventricular arrhythmias (in 33 patients) that were either induced during EP investigations or spontaneously occurring. The 47 arrhythmias were consecutive, and some patients who experienced spontaneous arrhythmias also had induced arrhythmias; therefore, it is presumed the spontaneous arrhythmias were in patients being attended to in the clinic. Data in this study were reported individually for each arrhythmia, but only induced arrhythmias were included in the current Review. Eighteen patients with 20 induced arrhythmias are included in this study.

Miller 1985 is a prospective US study in a cardiac EP laboratory and included nine patients paced into VT (11 arrhythmias).

Table 3.5 Characteristics of included studies of PT for arrhythmia induced during EP investigations

Study ID	Study design Country, study setting Period	Population	Eligible cardiac arrhythmias	Intervention (PT)	Outcomes
Haman 2009	Prospective single cohort study Czech Republic May 2001 to Dec 2007 N = 155 pts	Consecutive patients undergoing EP studies for assessment of primary or secondary prevention of SCD, who experienced VT that was non-tolerated or VF CA status not reported.	• VT • VF	PT as first manoeuvre, followed by defibrillation.	• successful method of cardioversion • conversion to other arrhythmia • adverse events
Amir 2007	Prospective cohort study Israel; Technion-Israel Institute of Technology, Haifa Period NR N = 80 pts	Consecutive patients who, during their EP studies, developed a hemodynamically unstable malignant tachyarrhythmia or to patients who had ICD implantation and a malignant VT was induced for defibrillation threshold testing. Patients with sternal instability were excluded from the study. CA status not reported.	• VT • VF	PT as first manoeuvre, followed by standard cardioversion (internal or external).	• successful method of cardioversion • conversion to other arrhythmia [16] • adverse events
Volkmann 1990	Prospective cohort study Germany (Friedrich Schiller University, Jena)[17] Period NR N = 47 arrhythmias (eligible arrhythmias n = 20)	Consecutive patients undergoing EP examination or pacemaker implantation or experiencing spontaneous arrhythmias.[18] CA status not reported.	• VT • VF • V-flutter	PT as a first manoeuvre, with following interventions determined by status of patient, but including further individual thumps, potentially followed by rapid bursts of PT, and finally followed by standard cardioversion (e.g. defibrillation, RVS).	• successful method of cardioversion • conversion to other arrhythmia • adverse events
Miller 1985	Prospective case series US (location NR) Period NR N = 9 pts (11 arrhythmias)	Patients in the cardiac EP laboratory with electrically induced sustained VT. Not in CA ('not arrested').	• VT	PT as first manoeuvre, followed by overdrive pacing or countershock.	• successful method of cardioversion • conversion to other arrhythmia.

Abbreviations: CA, cardiac arrest; EP, electrophysiology; ICD, implantable cardioverter defibrillator; NR, not reported; PT, precordial thump; RVS, right ventricular stimulation; SCD, sudden cardiac death; VF, ventricular fibrillation; V-flutter, ventricular flutter; VT, ventricular tachycardia.

[16] Statement made that no rhythm deterioration occurred, defined as no change from VT to VF.
[17] Department of cardiology and angiology of the clinic for internal medicine.
[18] Some patients that experienced spontaneous arrhythmias also had induced arrhythmias – it is presumed that patients with spontaneous arrhythmias were attended to in the clinic where EP investigations took place.

3.4.2 Patient population

Cardiac arrest

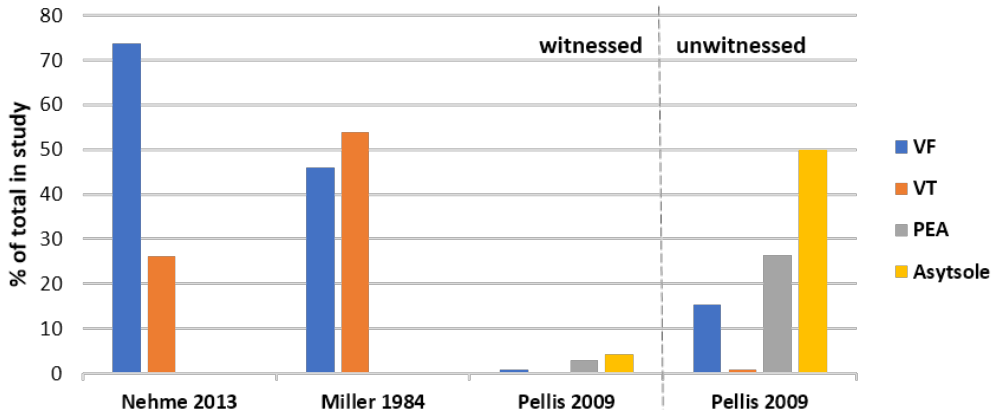
All three studies investigated patients with OHCAs. Table 3.6 shows the study populations by witness status and cardiac rhythm. The Nehme 2013 and Miller 1984 studies were restricted to EMS-witnessed CA and to patients with either VT or VF.[19] In contrast, only 8% of patients in Pellis 2009 had a witnessed arrest, of which only one had VF and none had VT. Among the unwitnessed CAs, only one was VT. This study, therefore, has a population of mainly unwitnessed CA patients in non-shockable rhythms (asystole, 54%; PEA, 29%) with only a small proportion in VF (16%). A comparison of the presenting rhythms in these studies is shown in Figure 3.1.

Table 3.6 Patients in cardiac arrest studies, by cardiac rhythm and EMS-witness status

Cardiac rhythm (N)		PT cohort				Defibrillation/non-PT cohort			
Study ID	Witness status	**VT**	**VF**	**PEA**	**Asystole**	**VT**	**VF**	**PEA**	**Asystole**
Nehme 2013	Witnessed	27	76	–	–	96	229	–	–
Miller 1984	Witnessed	27	23	–	–	–	–	–	–
Pellis 2009	Witnessed	0	1[20]	4	6	0	NR	NR	NR
	Unwitnessed	1[21]	22	38	72	0	NR	NR	NR
	Total	*1*	*23*	*42*	*78*	*0*	*42*	*59*	*118*

Note: For Pellis 2009, proportions shown are of each cohort (i.e. witnessed plus unwitnessed) are shown.
Abbreviations: EMS, emergency medical service; PEA, pulseless electrical activity; PT, precordial thump; VF, ventricular fibrillation; VT, ventricular tachycardia.

Figure 3.1 Proportion of presenting arrhythmias in the three CA studies



Abbreviations: CA, cardiac arrest; PEA, pulseless electrical activity; VF, ventricular fibrillation; VT, ventricular tachycardia.
Arrhythmias are presented as a proportion of each study. The majority of patients in the Pellis 2009 study had unwitnessed CA, while all patients in the Nehme 2013 and Miller 1984 studies had witnessed CA.

Induced arrhythmia

By nature of the experimental design, the induced arrhythmias in all studies were monitored, and the patients were being investigated for, arrhythmia problems or had known underlying cardiac conditions. Table 3.7 shows the number of arrhythmias treated in each of the induced arrhythmia studies.

[19] Patients in the Miller 1984 study presented with a range of rhythms (29 VF; 1 VT; 3 idioventricular rhythm; 6 asystole; 3 PEA; 8 normal sinus rhythm) but those not in VF/VT at presentation received PT only after developing VF/VT in the course of resuscitation.
[20] Table 2 of Pellis 2009 shows that of the 24 patients with VF/VT, one was EMS-witnessed. Since the entire PT cohort includes a single patient in VT, and that was unwitnessed CA (see following footnote), the single witnessed VF/VT patient must have had VF.
[21] Only one patient in the Pellis 2009 PT cohort presented with VT (legend of Table 1, Pellis 2009), which was unwitnessed (Table 4, Pellis 2009).

Patients in the Haman 2009 study were at risk of SCD and were undergoing EP studies. Only patients who became unconscious after induced VT (monomorphic or polymorphic) or VF were treated with PT, as the authors expressed a preference not to hit conscious patients. This is the only included study that imposed this limitation.

In the Amir 2007 study, eligible induced arrhythmias were sustained VT (monomorphic or polymorphic) and VF. Of the 80 patients in the study, 22 were undergoing EP studies and 58 ICD implantation, but results were not reported separately for these groups.

The 18 patients with induced arrhythmias in the Volkmann 1990 study were a subset of 33 consecutive patients. Eligible arrhythmias were VT, VF and ventricular flutter, with two patients experiencing more than one arrhythmia (Table 3.7). This is the only study that included ventricular flutter. Some patients progressed to CA in the course of the investigations (no palpable pulse, loss of consciousness).

In Miller 1985, nine patients were paced into VT, one on three occasions, making a total of 11 arrhythmias treated. None of the patients were in CA.

Table 3.7 Patients in induced arrhythmia studies, by induced rhythm

Study ID	Patients, N (total arrhythmias, where >N)	Induced rhythm (n)		
		VT	VF	V-flutter
Haman 2009	155	134[22]	21	–
Amir 2007	80	52[23]	28	–
Volkmann 1990	18 (20)	10	3	7
Miller 1985	9 (11)	11	–	–

Abbreviations: VF, ventricular fibrillation; V-flutter, ventricular flutter; VT, ventricular tachycardia.

3.4.3 Interventions

Cardiac arrest

Table 3.8 shows the reported descriptions of PT allocation, training in the technique, and details of standard care in the studies of patients in CA. As would be expected for retrospective studies, standard techniques were used in the Nehme 2013 and Miller 1984 studies, and the decision of whether to administer PT or to use other cardioversion manoeuvres would have been guided by the relevant clinical practice guidelines and emergency service operating procedures. As guidelines recommend PT as an option where defibrillation is delayed, presumably delayed defibrillation was a necessary factor in the cohort receiving PT in these retrospective studies.

In the Nehme 2013 study, there was no evidence of a delay in patients receiving an initial defibrillation, with a median time from cardiac arrest to first shock in both cohorts of 1.0 min (IQR 0.0-2.0). The time to first shock appears to have been measured in minutes rather than seconds. If that is the case, it is possible that any delay to defibrillation in the defibrillation-first cohort was less than a minute, making the scale of the measure insufficiently sensitive to detect a difference between the groups. As guidelines typically recommend PT as an option rather than a directive, the final decision to use PT in these studies is likely to have been impacted by the level of expertise and preferences of the attending EMS personnel.

Delayed access to defibrillation is not described as a reason to administer PT in the prospective Pellis 2009 study; according to the protocol, PT was to be administered to all patients receiving CPR regardless of presenting rhythm, after connection to a defibrillator and prior to any other interventions. Patients receiving this treatment protocol formed the PT study cohort while those that did not formed the

[22] VT was monomorphic in 65 and polymorphic in 69 patients.
[23] VT was monomorphic in 20 and polymorphic in 32 patients

comparator cohort. Reasons for departure from the protocol were not described, but again are likely to be related to the expertise/preferences of attending EMS personnel. This study also used standard techniques rather than specific training for the purposes of the study, in order to capture real-world EMS practice.

Table 3.8 Descriptions of PT application, training and standard care details for studies of cardiac arrest

Study ID	Intervention allocation	PT training	Following care	Availability of defibrillators	Time to first defibrillation
Nehme 2009	Cardiac arrest treatment guidelines follow the recommendations of the Australian Resuscitation Council, which are similar to its international counterparts. A single PT was advised if the patient suffered a monitored episode of VT/VF and defibrillation was not immediately possible.	All paramedics were capable of performing rhythm interpretation, defibrillation or PT administration as required.	"ThumpFirst" group received an immediate PT and ongoing resuscitation efforts as appropriate.	During the study period, all ambulances were equipped with electrical defibrillators and heart monitors as a single device.	PT cohort median 1.0 min; IQR 0.0-2.0 Shock-first cohort median 1.0 min; IQR 0.0-2.0
Pellis 2009	All patients in CA (confirmed according to the 2000 ILCOR guidelines) for whom it was decided to attempt CPR were regarded as qualifying for this study. After placing defibrillation pads on the victim, a pre-cordial chest thump was delivered before any other resuscitatory intervention, regardless of the presenting rhythm, and without notable delay in other procedures.	All EMS personnel were trained in Advanced Life Support, but did not receive specific training or instructions on how to perform PT, to obtain data pertinent to the typical 'real life' conditions.	Immediately after PT delivery, heart rhythm was automatically analysed … and resuscitation efforts were otherwise continued according to the 2000 ILCOR guidelines.	… heart rhythm was automatically analysed using the algorithm incorporated in the defibrillator (Philips Medical System, Heartstart 4000, Andover, MA, US)…	NR[24]
Miller 1984	When a patient's monitored rhythm is observed to deteriorate to VF or VT, a precordial thump … is delivered.	The precordial thump is taught as a part of the paramedic training program and is used in the ACLS and paramedic protocols for pulseless, nonbreathing patients.	Not described; some patients received 'cardioversion or countershock and/or medications'.	Not described, but does not include current defibrillator technologies (hand-held paddle electrodes were standard at time of study).	NR

Abbreviations: ACLS, advanced cardiac life support; CA, cardiac arrest; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; ILCOR, International Liaison Committee on Resuscitation; IQR, interquartile range; NR, not reported; PT, precordial thump; VF, ventricular fibrillation; VT, ventricular tachycardia.

[24] Time from EMS call to first intervention over 9 minutes for both groups (unclear whether mean or median reported, although IQR also reported so likely to be median).

Induced arrhythmia

Table 3.9 shows the reported descriptions of PT allocation, training in the technique, and details of standard care for the induced arrhythmias studies. In the Haman 2009 study, one of two cardiologists experienced with PT administered the thump according to their own judgement of appropriate force. It is presumed that PT was administered only once prior to defibrillation as no statement is made regarding repeated application.

PT was administered in the Amir 2007 study by one of four senior cardiologists (experience with PT not reported), without any attempt to unify the force applied. Only one thump was administered before standard cardioversion.

In the Volkmann 1990 study, PT was delivered by health care professionals with experience in the technique. A single PT was the first manoeuvre applied, but where cardioversion was not achieved with the initial attempt, successive attempts were made using either another individual PT and/or rapid bursts of PT. These rapid bursts were administered, where possible, at a frequency exceeding that of the tachycardia, based on the concept of overdrive pacing. As described in Section 3.4.5, the total number of such 'attempts' made for each arrhythmia is reported. The haemodynamic status of the patient influenced the number of successive PT applications attempted before standard cardioversion techniques were employed, as described in Table 3.9. The full details of the interventions used are shown for each induced arrhythmia in Appendix C, Table AppD.1.

A single PT was attempted in the Miller 1985 study prior to the use of standard cardioversion methods. The nature of any prior experience with PT was not reported.

Table 3.9 Descriptions of PT application, training and standard care details for studies of induced arrhythmias

Study ID	Study protocol	Description of PT	Following care
Haman 2009	All patients signed an informed written consent. Programmed ventricular stimulation was carried out from the right ventricular apex and outflow tract (via right heart catheterisation) in non-sedated patients without electrolyte abnormalities.	When induced VA was not tolerated, one of two participating experienced senior cardiologists applied PT immediately after the onset of unconsciousness (determined by non-responsiveness of the patient). PT was delivered in a consistent manner: clenched fist forcefully applied from the height of 20–30cm to the junction of the middle and lower third of the patient's sternum. Both cardiologists used an individual subjective force magnitude, typical for "real life" conditions. Retrospective characterisation of average impact energy was conducted using a specially developed PT impact-measuring device ("thump-o-meter").	When PT was ineffective, the arrhythmia was terminated by external electrical cardioversion. PT was applied during the charging of the defibrillator, so there were no delays in the application of external defibrillation when needed.
Amir 2007	According to our study protocol, PT was given as a first and single attempt to all the patients in the study. The PT was delivered 10-20 seconds following induction of the VT. In patients with an ICD implantation, the PT was given during the detection and charging time. The study was approved by the Helsinki Committee of the Lady Davis Carmel Medical Center, Haifa, Israel. All the patients who participated in the study signed informed written consent.	One of four senior cardiologists who participated in the study and was appropriately sterile, gave the thump from a height of 8–10 inches aimed to the junction of the middle and lower parts of the sternum. In order to mimic the "real life" situation, we did not attempt to generate a uniform range of force of the precordial thump, and all the participating physicians used an individual subjective force magnitude.	Once ventricular malignant tachyarrhythmia continued after the PT delivery, external or internal defibrillation were applied. In three patients two attempts of external cardioversion were needed.
Volkmann 1990	All patients gave written consent to the use of precordial thumps in the case of induced VT or VF/V-flutter. In patients with spontaneous rhythm disturbances, a brief explanation was given about the therapeutic goal of the intervention before administering PT, and patients provided verbal consent.	The mechanical stimulation of the heart took place with thumps on the area of the precordium to the left half of the lower sternum. For this purpose, the closed fist was intentionally "dropped" from a height of 30-40 cm to this thorax region. The impact force was increasingly strengthened, depending on the result. PT was performed by one of two therapists who had extensive experience with PT in bradycardia. Initially a single application of PT was administered, followed by further PT if necessary as described in 'Following care'.	Conscious patients with palpable pulse: up to two additional individual PTs, followed by a series of 2-8 rapid bursts of PT, repeated up to 10 times. Unconscious patients with no palpable pulse: one additional PT followed by one series of 2-7 rapid bursts of PT (all administered during defibrillator preparation). Rapid bursts of PT were administered when individual thumps were not successful, at a frequency exceeding that of the tachycardia if possible. All patients not cardioverted with PT were given standard cardioversion (e.g. defibrillation, RVS, pharmacotherapy).
Miller 1985	A precordial thump protocol study form was filled out with the patient's age, sex, cardiac history, current medications, previous electrophysiology results, induction, ventricular tachycardia cycle length, morphology and duration with a summary of the effects of the precordial thump and subsequent manoeuvres done on the patient. The results of the precordial thump and all further manoeuvres were recorded.	The thump was delivered using the fleshy part of the hypothenar eminence from a height of eight to 12 inches above the sternum.	If the thump was unsuccessful, other methods were employed (i.e., overdrive pacing or cardioversion).

Abbreviations: ICD, implantable cardioverter defibrillator; PT, precordial thump; RVS, right ventricular stimulation; VA, ventricular arrhythmia; VF, ventricular fibrillation; V-flutter, ventricular flutter; VT, ventricular tachycardia.

3.4.4 Comparators

Cardiac arrest

Nehme 2013 and Pellis 2009 both compared patients who received PT as the first resuscitative manoeuvre with patients who received other types of cardioversion. In the case of Nehme 2013, all eligible patients received either PT or defibrillation as the first manoeuvre. In the Pellis 2009 study, the comparator group consisted of any patients who did not receive PT as the first resuscitative manoeuvre (non-PT cohort). The Miller 1984 study did not include a comparator group.

Induced arrhythmia

The studies of induced arrhythmia did not include a comparator group.

3.4.5 Outcomes

Cardiac arrest

Among the studies, the following outcomes were reported:

- ROSC after first manoeuvre
- overall ROSC
- pulse on arrival at hospital (Nehme 2013 only)
- survival to hospital discharge
- rhythm change without ROSC
- no rhythm change after first manoeuvre (not extracted in this Review).

The Miller 1984 study did not refer specifically to ROSC – improved rhythm after PT was reported, and whether a pulse was restored (i.e. ROSC). Resuscitation after subsequent CPR (overall ROSC) was also reported.

Despite not being specified in the PICO, data were extracted for all rhythm change outcomes from all CA studies. The Nehme 2013 study refers to some rhythm changes as rhythm deterioration (e.g. a change from VT into VF or other non-shockable rhythm), and are regarded by the study authors as a 'potentially harmful change'. Similarly, the Miller 1984 study classified rhythm changes as either 'improved' or 'worse'. The Pellis 2009 study reported specific rhythm changes without reference to harms.

No studies reported neurologically intact survival.

Induced arrhythmia

The Haman 2009 and Amir 2007 studies reported whether cardioversion was successful after PT and after subsequent standard cardioversion, reported by arrhythmia type. Rhythm deterioration and adverse events were also reported.

The Volkmann 1990 study reported outcomes for each instance of an arrhythmia, tabulating results separately for successful cardioversion with PT (either after an individual PT or rapid bursts of PT) and unsuccessful cardioversion with PT. All patients not cardioverted with PT were successfully cardioverted with standard care. For each arrhythmia, the number of PT cardioversion attempts was reported, as well as the maximum number of PTs used across all attempts for that arrhythmia. From this information it was possible to infer the number of arrhythmias converted with a single PT and how many were converted with rapid bursts of PT. The full details of the interventions used and the eventual, successful cardioversion method are shown for each induced arrhythmia in Appendix C, Table AppD.1. Rhythm deterioration was also reported.

The impact of PT and the method that successfully restored normal rhythm were reported separately for each of the 11 arrhythmias in the Miller 1985 study. Rhythm deterioration was also reported.

3.5 RISK OF BIAS OF INDIVIDUAL STUDIES

3.5.1 Assessment of risk of bias of individual studies

As described in the methodology section (Section 2.7), the current Evidence Review used the SIGN Methodology Checklist 3 for Cohort Studies for comparative studies and the JBI Checklist for Case Series for the single cohort/consecutive case series studies (the Miller 1985 study was also assessed with this JBI tool, although the consecutive status of this case series is unclear).

One form was completed per study (see Appendix E). The Pellis 2009 study provides both comparative data and single cohort data, but was assessed once, using the tool for comparative studies (SIGN). In all studies, all outcomes were associated with similar risk of bias, leading to a single assessment of quality for each study.

3.5.2 Summary of risk of bias of individual studies

The risk of bias in each of four domains (eligibility criteria, exposure/outcome, confounding, follow up) is summarised for each study in Table 3.10. Study design does not impact on the risk-of-bias assessment here, as the inherent risks associated with study design are captured in the process of grading the body of evidence (which starts with taking study design into account). Rather, the risk of bias of an individual study is assessed within the framework of a particular study design (e.g. cohort with control group, single cohort study), using the appropriate critical appraisal tool. However, retrospective studies can be downgraded here if, for example, insufficient details are reported of the record capture process.

Each study was assigned an overall risk of bias (low, moderate or high; Table 3.10). No difference in potential risk across outcomes was identified, so the overall risk of bias relates to all outcomes.

As mentioned earlier, the Pellis 2009 study was appraised using the SIGN Methodology Checklist 3 for cohort studies as some data compared a control group to the PT intervention group. For these outcomes, this study was deemed to have a moderate risk of bias. However, this study mainly presents single cohort data for patients who received PT. These outcomes could have been assessed with the JBI checklist for case series – such an assessment would have also found a moderate risk of bias, as it is not clear why some patients received PT and others did not, so it is unclear whether the sample is representative.

Table 3.10 Risk of bias of individual studies – summary table

Study ID Study design Appraisal tool	Risk of bias				Overall risk of bias
	Eligibility criteria	Exposure/outcome	Confounding	Follow up	
Primary question: PT for cardiac arrest					
Nehme 2013 retrospective comparative **SIGN**	**Unclear** Patient selection for PT not rigorous, but was guided by CPGs, so reflects real-world application.	**Low** No serious bias concerns. Some PT events may have been missed as PT is not a core reporting element in VACAR and was extracted from patient records.	**Low** No adjustment for potential confounders, but not a serious source of concern (groups appear balanced).	**Low** ROSC outcomes: No concerns. Survival to discharge: No concerns: hospital records of discharge/ mortality would be reliable for retrospective data.	**Low** Unclear risk from treatment allocation. Retrospective but database would be relatively reliable.
Pellis 2009 prospective comparative/ non-comparative **SIGN**	**High** Lack of clarity regarding treatment allocation (all patients in CA were eligible for PT but not all received PT).	**Unclear** Prospective study but data collection not described.	**Low** No adjustment for potential confounders, but not a serious source of concern (groups appear balanced apart from bystander CPR – higher in non-PT cohort).	**Low** ROSC outcomes: No concerns. Survival to discharge: No concerns.	**Moderate** Inconsistent treatment allocation (no reasons given), and data collection not described.
Miller 1984 retrospective non-comparative **JBI**	**High** No information regarding eligibility criteria.	**High** Data collection not described. Risk due to retrospective design.	**Low** No accounting for potential confounders, but not a serious source of concern.	**Low** ROSC outcomes: No concerns Survival to discharge: NR	**High** Limitations in multiple criteria (unclear definition of eligible cohort, retrospective design).
Supplementary question: PT for induced arrhythmia					
Haman 2009 prospective non-comparative **JBI**	**Low** All consecutive patients with induced arrhythmia.	**Low** No concerns.	**Low** No accounting for potential confounders, but not a serious source of concern.	**Low** Arrhythmia termination/change follow up is immediate, no concerns.	**Low** No concerns.
Amir 2007 prospective non-comparative **JBI**	**Unclear** Apparently all consecutive patients with induced arrhythmia (all consecutive patients who gave consent, numbers not reported)	**Low** No concerns.	**Low** No accounting for potential confounders, but not a serious source of concern.	**Low** Arrhythmia termination/change follow up is immediate, no concerns.	**Low** No concerns apart from potential issue of representativeness of sample (unclear rate of non-consenting patients).
Volkmann 1990 prospective non-comparative **JBI**	**Low** All consecutive patients with induced arrhythmia.	**Low** No concerns.	**Low** No accounting for potential confounders, but not a serious source of concern.	**Low** Arrhythmia termination/change follow up is immediate, no concerns.	**Low** No concerns.
Miller 1985 prospective **JBI**	**High** No mention of consecutive patients, or all patients that meet eligibility criteria (i.e. representativeness of sample unclear). Demographics and location not reported.	**Low** No concerns.	**Low** No accounting for potential confounders, but not a serious source of concern.	**Low** Arrhythmia termination/change follow up is immediate, no concerns.	**High** Major concerns regarding representativeness of sample due to lack of patient selection information.

Abbreviations: CPG, clinical practice guideline; CPR, cardiopulmonary resuscitation; PT, precordial thump; ROSC, return of spontaneous circulation; VACAR, Victorian Ambulance Cardiac Arrest Registry.

3.6 DATA EXTRACTION

The two studies reporting comparative data (Nehme 2013; Pellis 2009) calculated ORs only. However, as all estimates were unadjusted, it was feasible to calculate RRs post hoc using Review Manager 5.3 for the purposes of this Review. Similarly, where only raw data were reported, they were used to calculate RRs post hoc.

3.6.1 Cardiac arrest studies – comparative data

ROSC and survival outcomes

The Nehme 2013 study investigated patients in EMS-witnessed cardiac arrest, presenting with either VT or VF. After the first manoeuvre, patients who received PT were significantly less likely to cardiovert than those who received defibrillation (RR 0.08, 95% CI: 0.04, 0.20), with similar differences observed regardless of presenting rhythm (Table 3.11). The use of PT, however, did not appear to compromise subsequent resuscitation interventions as similar overall ROSC was observed in both PT-first and defibrillation-first groups.

Table 3.11 ROSC and survival outcomes after PT first versus defibrillation first for witnessed CA – Nehme 2009

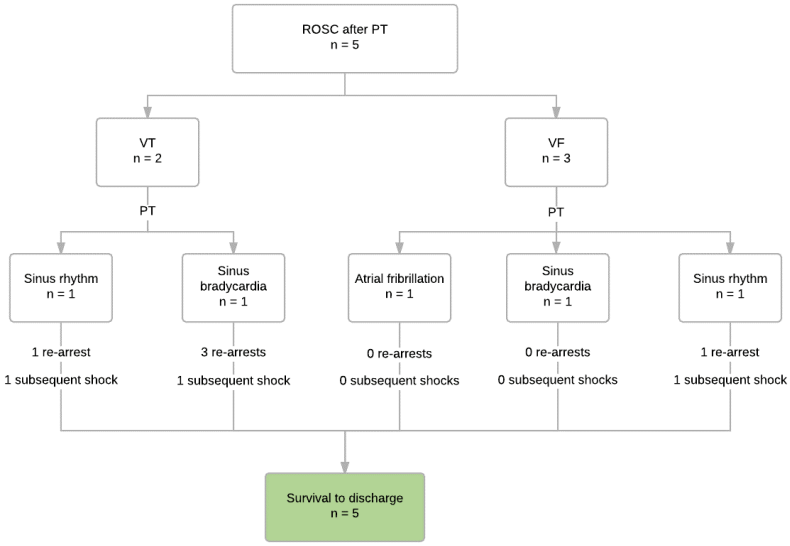
Outcome	Presenting rhythm – witnessed	PT first n/N	PT first (%)	Defibrillation first n/N	Defibrillation first (%)	Unadjusted OR [95% CI]	RR [95% CI] (calculated post hoc)
ROSC after first manoeuvre	VT/VF	5/103	(4.9)[25]	188/325	(57.8)	**OR 0.04 [0.01, 0.09]**	**RR 0.08 [0.04, 0.20]**
	VT	2/27	(7.4)[26]	54/96	(56.3)	**OR 0.06 [0.01, 0.28]**	**RR 0.13 [0.03, 0.51]**
	VF	3/76	(3.9)[27]	134/229	(58.5)	**OR 0.03 [0.01, 0.10]**	**RR 0.07 [0.02, 0.21]**
Overall ROSC	VT/VF	96/103	(93.2)[28]	292/325	(89.8)	OR 1.55 [0.66, 3.62]	RR 1.04 [0.97, 1.11]
Pulse at hospital arrival	VT/VF	86/103	(83.5)	256/325	(78.8)	OR 1.28 [0.71, 2.31]	RR 1.06 [0.96, 1.17]
Survival to discharge	VT/VF	73/103	(70.9)	228/325	(70.2)	OR 1.02 [0.62, 1.66]	RR 1.01 [0.88, 1.17]

Abbreviations: CA, cardiac arrest; CI, confidence interval; OR, odds ratio; PT, precordial thump; RR, relative risk; ROSC, return of spontaneous circulation; RR, relative risk; VF, ventricular fibrillation; VT, ventricular tachycardia.
Note: Risk estimates in bold indicate a statistically significant difference. VT is pulseless VT.

Figure 3.2 shows the outcomes in the five patients who experienced ROSC after PT. Three patients re-arrested and received defibrillation. All five patients survived to discharge.

[25] Three patients experienced further cardiac arrest after PT, requiring rescue defibrillation (one VT and two pulseless VF).
[26] Both patients required rescue defibrillation after PT; one converted to sinus rhythm after PT, but experienced a total of 2 arrests, while the other converted to sinus bradycardia after PT but experienced a total of 4 arrests.
[27] One patient converted to sinus rhythm after PT but experienced a further cardiac arrest, requiring rescue defibrillation.
[28] ROSC was achieved in five patients with PT, but three experienced additional arrests and received defibrillation.

Figure 3.2 Outcomes subsequent to ROSC after PT in the Nehme 2013 study



Abbreviations: PT, precordial thump; ROSC, return of spontaneous circulation; VF, ventricular fibrillation; VT, ventricular tachycardia.

In the Pellis 2009 study, CA was largely unwitnessed (92% of the PT group; 91% of the non-PT group), and was largely non-shockable (asystole/PEA: 83% of the PT group; 81% of the non-PT group – described earlier in Section 3.4.2**,** Table 3.6). This study did not define the first manoeuvre used in the non-PT comparator group[29] and there are no data presented for ROSC after the first intervention, and overall ROSC only is reported (Table 3.12). The use of PT, however, did not appear to compromise subsequent resuscitation interventions, as similar overall ROSC was observed in both PT-first and non-PT groups. Outcomes for the three patients who experienced ROSC after PT is shown in the following section (Section 3.6.2).

Table 3.12 ROSC and survival outcomes after PT first versus non-PT for largely unwitnessed CA – Pellis 2009

Outcome	Presenting rhythm	PT first (92% unwitnessed)		Non-PT CPR (91% unwitnessed)[30]		Unadjusted OR [95% CI]	RR [95% CI] (calculated post hoc)
		n/N	(%)	n/N	(%)		
ROSC after first manoeuvre	VF/PEA/asystole[31]	3/144	(2.1)	NR		–	–
Overall ROSC	VF/PEA/asystole	31/144	(21.5)	43/219	(19.6)	NR	RR 1.10 [0.73, 1.65]
Survival to discharge	VF/PEA/asystole	8/144	(5.6)	14/219	(6.4)	NR	RR 0.87 [0.37, 2.02]

Abbreviations: CA, cardiac arrest; CI, confidence interval; CPR, cardiopulmonary resuscitation; NR, not reported; OR, odds ratio; PEA, pulseless electrical activity; PT, precordial thump; RE, risk estimate; ROSC, return of spontaneous circulation; RR, relative risk; VF, ventricular fibrillation; VT, ventricular tachycardia.
Note: Risk estimates in bold indicate a statistically significant difference. Where not reported, % calculated post hoc.

Survival to hospital and to discharge after witnessed CA were similar for PT-first and defibrillation-first groups in the Nehme 2013 study (Table 3.11). Similarly, in the Pellis 2009 study, no significant difference in survival to discharge was observed between PT-first and non-PT groups of largely unwitnessed CA (Table 3.12). Therefore, no compromise in overall survival after PT has been observed for either witnessed or unwitnessed CA.

[29] Given the proportion of non-shockable presenting rhythms in this study, pharmacological cardioversion was probably frequently used rather than defibrillation.
[30] Results by witness status not reported for 'Non-PT CPR' group.
[31] See Table 3.2 for proportions of each cardiac rhythm. As only one patient across both cohorts of this study had VT, this rhythm is not listed here.

The marked difference in survival to discharge between studies is presumed to be due, at least in part, to the unwitnessed status of almost all the CAs in the Pellis 2009 study. Overall survival for witnessed CA was 36% (Table 3.14 in the following section), although the sample size of 11 for this subgroup is small.

Rhythm change without ROSC

Only the Nehme 2013 study reported comparative results for rhythm change without ROSC (Table 3.13). A change from VT to VF or from VT/VF to an unshockable rhythm (PEA or asystole) was referred to by the study authors as rhythm deterioration, and is used here to define 'any rhythm deterioration'.

For VT/VF, rates of any rhythm deterioration were not significantly different between PT and defibrillation (RR 0.79 [0.41, 1.52]). However, deterioration to a non-shockable rhythm was more frequent after defibrillation (RR 0.18 [0.04, 0.74]).

Patients with VT experienced significantly more rhythm deterioration after PT (RR 2.91 [1.35, 6.29]) whereas patients with VF experienced significantly more rhythm deterioration after defibrillation (RR 0.10 [0.01, 0.75]). Outcomes are shown for the 10 patients who experienced rhythm deterioration after PT in Figure 3.3.

Table 3.13 Rhythm change only after PT first versus defibrillation first for witnessed CA – Nehme 2009

Outcome	Presenting rhythm – witnessed	PT first		Defibrillation first		Unadjusted OR [95% CI]	Unadjusted RR (calculated post hoc)
		n/N	(%)	n/N	(%)		
Rhythm change only	VT/VF to any other rhythm	12/103	(11.6)	40/325	(12.3)	OR 0.94 [0.47, 1.87]	RR 0.95 [0.52, 1.73]
	Any deterioration of VT/VF[32]	10/103	(9.7)	40/325	(12.3)	NR	RR 0.79 [0.41, 1.52]
	VT/VF to unshockable rhythm	2/103	(1.9)	40/325	(12.3)	NR	**RR 0.18 [0.04, 0.74]**
	VT to any other rhythm	9/27	(33.3)	11/96	(11.5)	**OR 3.86 [1.4, 10.68]**	**RR 2.91 [1.35, 6.29]**
	VT to VF	8/27	(29.6)	0/96	(0.0)	NR	**RR 58.89 [3.51, 989.03]**[33]
	VT to unshockable rhythm	1/27	(3.7)	11/96	(11.5)	NR	RR 0.32 [0.04, 2.39]
	VT to PEA	1/27	(3.7)	4/96	(4.2)	NR	RR 0.89 [0.10, 7.63]
	VT to asystole	0/27	(0.0)	7/96	(7.3)	NR	RR 0.23 [0.01, 3.92]
	VF to any other rhythm	3/76	(3.9)	29/229	(12.7)	**OR 0.28 [0.08, 0.96]**	**RR 0.31 [0.10, 0.99]**
	VF to VT	2/76	(2.6)	0/229	(0.0)	NR	RR 14.94 [0.72, 307.69][33]
	VF to unshockable rhythm	1/76	(1.3)	29/229	(12.7)	NR	**RR 0.10 [0.01, 0.75]**
	VF to PEA	0/76	(0.0)	12/229	(5.2)	NR	RR 0.12 [0.01, 1.99]
	VF to asystole	1/76	(1.3)	17/229	(7.4)	NR	RR 0.18 [0.02, 1.31]

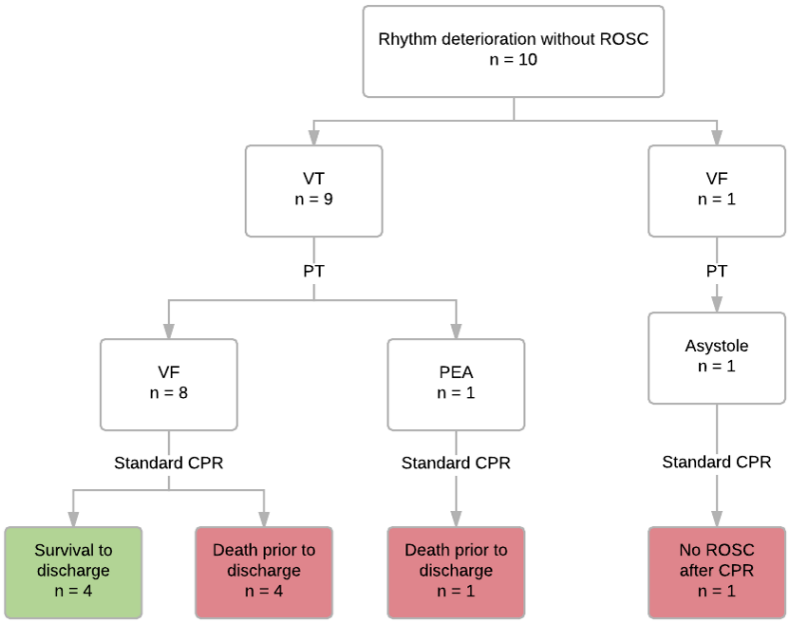
Abbreviations: CA, cardiac arrest; CI, confidence interval; NR, not reported; OR, odds ratio; PT, precordial thump; PEA, pulseless electrical activity; RE, risk estimate; ROSC, return of spontaneous circulation; RR, relative risk; VF, ventricular fibrillation; VT, ventricular tachycardia.
Note: Risk estimates in bold indicate a statistically significant difference. Where not reported, % calculated post hoc. Unshockable rhythm refers to PEA or asystole. Where an OR is not shown, subgroup comparisons were not reported in the Nehme 2013 publication and were analysed post hoc for the current Review.

The authors note that deterioration from VT to VF is known to occur soon after the onset of cardiac arrest, and that the excess of deterioration from VT to VF in the PT group may be due to factors other than the administration of PT. In light of the lower rates of cardioversion after PT compared to defibrillation, a greater proportion of patients remain in VT after the first manoeuvre in the PT group, providing the opportunity for this natural deterioration to occur. The median time to first shock is reported for both the PT-first and defibrillation-first groups as 1.0 min (IQR 0.0-2.0). However, as discussed in Section 3.4.3, this statistic may fail to distinguish clinically significant differences in time to defibrillation between the groups, as it appears to have been measured in minutes rather than seconds. Therefore, as noted by the authors of the study, the cause of the excess change from VT to VF after PT is unclear.

[32] Deterioration is a change from VT to any other rhythm and VF to an unshockable rhythm.
[33] As no events occurred in the comparator cohort, there is no risk in comparator group that can be changed by PT, making relative risk meaningless and creating a very high upper confidence interval.

Figure 3.3 shows the subsequent outcomes in the 10 patients (9.7%) who experienced rhythm deterioration after PT. Eight patients with VT were thumped into VF, of which four survived to discharge. The single patient thumped from VT to PEA and the single patient thumped from VF to asystole did not survive. Individual outcomes were not reported for the 40 patients (12.3%) who experienced rhythm deterioration after defibrillation (all changed to unshockable rhythms).

Figure 3.3 Outcomes subsequent to rhythm deterioration in the PT cohort of the Nehme 2013 study



Abbreviations: CPR, cardiopulmonary resuscitation; PEA, pulseless electrical activity; PT, precordial thump; ROSC, return of spontaneous circulation; VF, ventricular fibrillation; VT, ventricular tachycardia

Note: Two additional patients experienced rhythm change without ROSC after PT, but they were thumped into an improved rhythm (VF to VT).

In Pellis 2009 study, no data for the comparison group (non-PT CPR) were reported for rhythm change without ROSC. Results for the PT cohort, however, are reported in the following section (Section 3.6.2).

3.6.2 Cardiac arrest studies – non-comparative data

The Pellis 2009 study included a variety of patients (e.g. witnessed CA or unwitnessed CA; VT or VF or PEA or asystole). Consequently, when results are shown by witness status and by presenting rhythm, sample sizes can be very small. For example, only a single patient had unwitnessed VT and another had witnessed VF, making these essentially case reports. Although shown, these results are mostly not discussed here. In addition to tabulated data, patient flow diagrams are shown, which capture 'No ROSC after standard CPR' and show survival by mode of resuscitation in the Pellis 2009 study (Figure 3.4), and rhythm changes and resuscitation outcomes in the Miller 1984 study (Figure 3.5; survival to discharge not reported).

In neither study did patients with VF experience ROSC as a result of PT. Similar rates of subsequent cardioversion with standard CPR were observed for witnessed CA (52%; Miller 1984) and unwitnessed CA (41%; Pellis 2009), with 14% of patients in the latter study surviving to discharge.

PT cardioverted two patients (7.4%) with witnessed VT in the Miller 1984 study, with a further nine (33%) resuscitated with subsequent CPR (survival outcomes not reported).

Among six patients with witnessed asystole in the Pellis 2009 study, PT resulted in ROSC in three, two of which survived to discharge (Figure 3.4). None of the 72 patients with unwitnessed asystole in this study, however, experienced ROSC after PT, and only 10 (14%) did so with subsequent CPR. One of these patients (1.4%) survived to discharge.

Similar outcomes were observed for unwitnessed PEA: ROSC was achieved after standard CPR only (10%), and none survived to discharge. Among four cases of witnessed PEA, ROSC was not achieved by any means.

Table 3.14 Outcomes after PT first for CA in single cohorts – Pellis 2009 and Miller 1984

Outcome	Presenting rhythm	Pellis 2009				Miller 1984	
		Witnessed		Unwitnessed		Witnessed	
		n/N	(%)	n/N	(%)	n/N	(%)
ROSC after PT	**All rhythms in study**	**3/11**	**(27.3)**	**0/133**	**(0.0)**	**2/50**	**(4.0)**
	VT	–		0/1	(0.0)	2/27	(7.4)[34]
	VF	0/1	(0.0)	0/22	(0.0)	0/23	(0.0)
	PEA	0/4	(0.0)	0/38	(0.0)	–	
	Asystole	3/6	(50.0)	0/72	(0.0)	–	
ROSC after post-PT standard CPR	**All rhythms in study**	**4/8**[35]	**(50.0)**	**24/133**	**(18.0)**	**21/25**	**(84.0)**
	VT	–		1/1	(100.0)	9/27	(33.3)
	VF	1/1	(100.0)	9/22	(40.9)	12/23	(52.2)
	PEA	0/4	(0.0)	4/38	(10.5)	–	
	Asystole	3/3	(100.0)	10/72	(13.9)	–	
Overall ROSC after all resuscitative manoeuvres	**All rhythms in study**	**7/11**	**(63.6)**	**24/133**	**(18.0)**		
	VT	–		1/1	(100.0)	11/27	(40.7)
	VF	1/1	(100.0)	9/22	(40.9)	12/23	(52.2)
	PEA	0/4	(0.0)	4/38	(10.5)	–	
	Asystole	6/6	(100.0)	10/72	(13.9)	–	
Overall survival to discharge	**All rhythms in study**	**4/11**	**(36.4)**	**4/133**	**(3.0)**	**NR**	
	VT	–		0/1	(0.0)	NR	
	VF	1/1	(100.0)	3/22	(13.6)	NR	
	PEA	0/4	(0.0)	0/38	(0.0)	–	
	Asystole	3/6	(50.0)	1/72	(1.4)	–	
Rhythm change after PT without ROSC	**All rhythms in study**	0/11	(0.0)	3/133	(2.3)	**13/50**	**(26.0)**
	VT	0/0	(–)	1/1	(100.0)	13/27	(48.1)
	VT to VF	–		0/1	(0.0)	8/27	(29.6)[36]
	VT to PEA	–		1/1	(100.0)	1/27	(3.7)
	VT to asystole	–		0/1	(0.0)	3/27	(11.1)
	VT to SV rhythm	–		0/1	(0.0)	1/27	(3.7)[37]
	VF	0/1	(0.0)	0/22	(0.0)	0/23	(0.0)
	PEA	0/4	(0.0)	1/38	(2.6)[38]	–	
	Asystole	0/6	(0.0)	1/72	(1.4)[39]	–	

Abbreviations: CA, cardiac arrest; CPR, cardiopulmonary resuscitation; PEA, pulseless electrical activity; PT, precordial thump; ROSC, return of spontaneous circulation; SV, supraventricular; VF, ventricular fibrillation; VT, ventricular tachycardia.

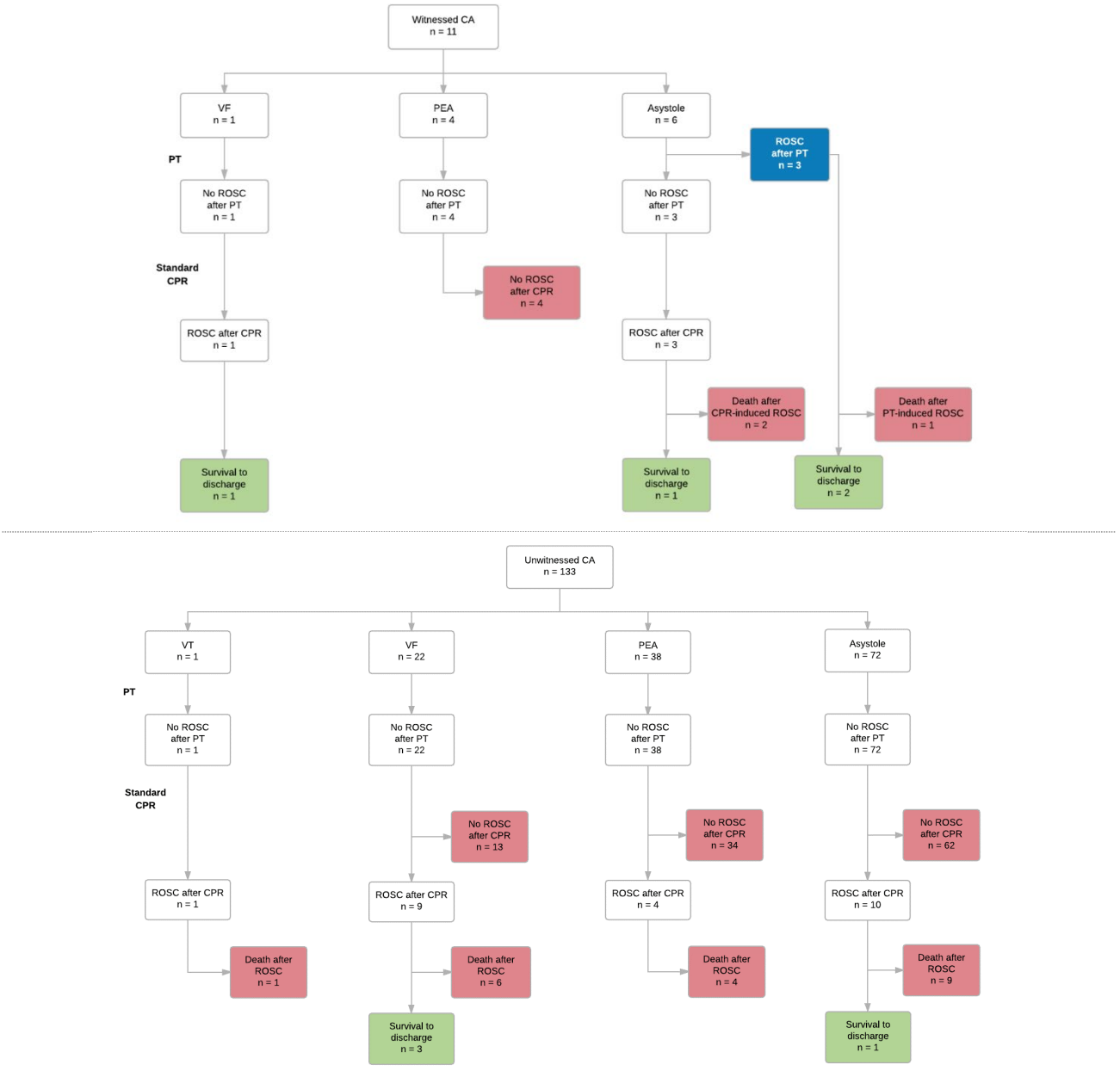
Rhythm change without ROSC was not observed in witnessed CA in the Pellis 2009 study, and in very few cases of unwitnessed CA (PEA to asystole, or vice versa, in less than 3% of cases). The single patient with VT in this study (unwitnessed CA) experienced rhythm deterioration to PEA and was resuscitated with standard CPR.

Higher rates of rhythm change without ROSC after PT were observed for cases of witnessed VT in the Miller 1984 study (48%), with 12 of the 13 cases being a deterioration of rhythm to VF, PEA or asystole

[34] While three patients in VT in the Miller 1985 study were thumped into a supraventricular rhythm, only two had pulses. Cardioversion of VT patients after PT is co-incidentally the same as for the Nehme 2013 study (2/27), and is not a data extraction error.
[35] Only eight of the 11 witnessed CA patients required standard CPR as three achieved ROSC with PT.
[36] Rhythm deterioration from VT to VF after PT is co-incidentally the same as for the Nehme 2013 study (8/27), and is not a data extraction error.
[37] This patient died in electromechanical dissociation (i.e. PEA), presumably after subsequent standard CPR.
[38] Changed to asystole.
[39] Changed to PEA.

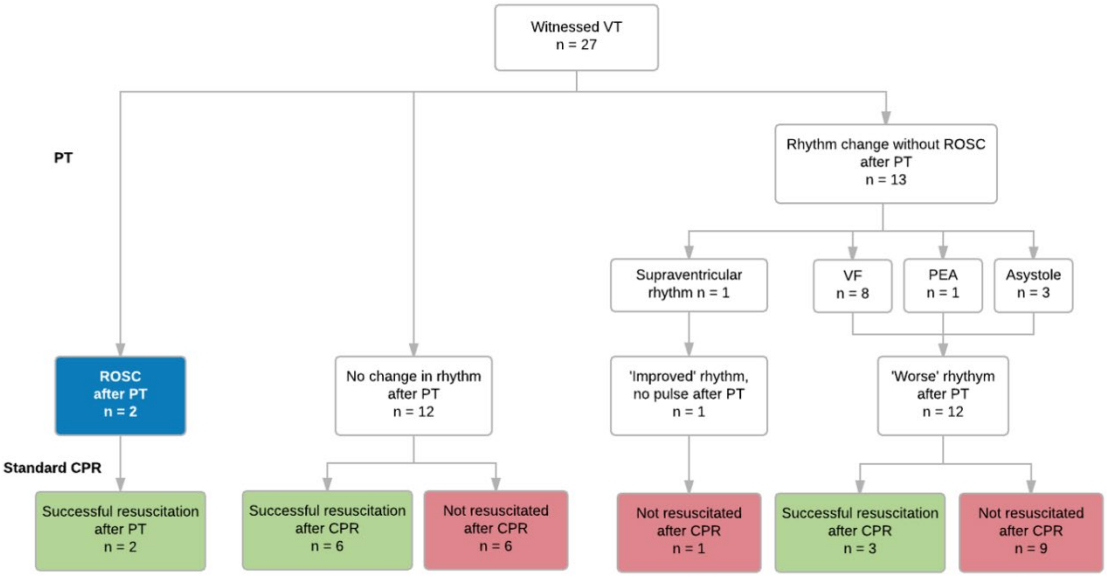
(Figure 3.5). Of these, three were successfully resuscitated with standard CPR, but the specific rhythms converted were not reported.

Figure 3.4 Patient flow for Pellis 2009 after PT first for witnessed and unwitnessed CA



Abbreviations: CA, cardiac arrest; CPR, cardiopulmonary resuscitation; PEA, pulseless electrical activity; PT, precordial thump; ROSC, return of spontaneous circulation; VF, ventricular fibrillation; VT, ventricular tachycardia.

Figure 3.5 Patient flow after PT first in patient with VT after witnessed CA – Miller 1984



Abbreviations: CPR, cardiopulmonary resuscitation; PEA, pulseless electrical activity; PT, precordial thump; ROSC, return of spontaneous circulation; VF, ventricular fibrillation; VT, ventricular tachycardia

3.6.3 Induced arrhythmia studies – non-comparative data

Table 3.15 Cardioversion and adverse outcomes after PT for induced arrhythmias

Outcome	Induced rhythm	Haman 2009 n/N	Haman 2009 (%)	Amir 2007 n/N	Amir 2007 (%)	Miller 1985 n/N	Miller 1985 (%)	Volkmann 1990 n/N	Volkmann 1990 (%)
No standard cardioversion required after single PT	VT	2/134[40]	(1.5)	1/52[41]	(1.9)	0/11	(0.0)[42]	0/7[43]	(0.0)
	VF	0/21	(0.0)	0/28	(0.0)	–		0/3	(0.0)
	V-flutter	–		–		–		0/7	(0.0)
No standard cardioversion required after all PT attempts (single thumps; rapid bursts)	VT	–		–		–		0/10	(0.0)
	VF	–		–		–		0/3[44]	(0.0)
	V-flutter	–		–		–		0/7[45]	(0.0)
Converted to other arrhythmia[46]	VT	0/134	(0.0)	0/52	(0.0)	0/11	(0.0)	0/10	(0.0)
	VF	0/21	(0.0)	NR[47]		–		0/3	(0.0)
	V-flutter	–		–		–		0/7	(0.0)
Adverse events		We did not observe any complications of PT application…		None of the patients had any injury either to his sternum/ribs…		NR		Acceleration of tachycardia … was never observed. Two patients experienced severe pain with PT – in both cases the intervention was terminated.	

Abbreviations: NR, not reported; PT, precordial thump; VF, ventricular fibrillation; V-flutter, ventricular flutter; VT, ventricular tachycardia.
Note: among the 27 spontaneous arrhythmias in the Volkmann 1990 study, all of which were VT, a single PT was successful in terminating one while a further 16 were terminated with rapid bursts of PT. These arrhythmias were excluded from this Review as they were not induced, but were included in the literature reviews supporting the 2010 ILCOR CoSTR.

[40] Both patients who cardioverted after PT had polymorphic VT.
[41] The patient who cardioverted after PT had monomorphic VT.
[42] Eleven arrhythmias in nine patients.
[43] Three VT arrhythmias were not treated with individual thumps, only rapid bursts of PT.
[44] Two VF arrhythmias were treated with multiple individual PTs, but not rapid bursts of PT.
[45] Three ventricular flutter arrhythmias were treated with multiple individual PTs, but not rapid bursts of PT.
[46] Data for the Volkmann 1990 study inferred from statement that in no patients was VT accelerated or VT or V-flutter initiated.
[47] The statement regarding rhythm deterioration is somewhat ambiguous. It may be that none of the 28 patients in VF deteriorated to an unshockable rhythm, or it may not have been regarded as deterioration, and so was not reported.

4 Narrative synthesis of findings

Immediate ROSC, rhythm change and termination of arrhythmias are discussed separately from overall ROSC and survival, as the former relate to the immediate effects of PT while the latter are longer term outcomes. Comparative results for immediate outcomes are reported only in the Nehme 2013 study. In Pellis 2009, comparative results are for overall ROSC and survival only (see Section 4.2), but immediate outcomes are reported for the PT cohort in this study.

4.1 IMMEDIATE ROSC AND RHYTHM CHANGES IN CARDIAC ARREST STUDIES

4.1.1 PT for ventricular tachycardia

A comparative cohort study of witnessed CA (Nehme 2013) found that after PT, patients with VT were significantly less likely to achieve immediate ROSC (7.4%) than after defibrillation (56.3%; RR 0.13 [95% CI: 0.03, 0.51]), and were significantly more likely to experience rhythm deterioration (33.3% versus 11.5%, RR 2.91 [1.35, 6.29]). In the PT cohort, most VT deteriorations were to VF, whereas in the defibrillation cohort, all deteriorations were to non-shockable rhythms (3.7% versus 11.5% for PT and defibrillation, respectively; not a statistically significant difference).

VT is known to deteriorate to VF shortly after the onset of CA. As discussed in Section 3.6.1, the time spent in witnessed CA prior to the first shock was not reported in sufficient detail to ascertain whether minor but potentially clinically significant differences of less than a minute may have existed between the PT and defibrillation groups, and so it is not clear whether the observed excess rhythm deterioration in the PT-first group is associated with the intervention or with a longer period in CA.

A single cohort study of PT for witnessed CA (Miller 1984) reported immediate ROSC in 7% of VT patients and rhythm deterioration from VT to VF in 29% – similar rates as observed in the Nehme 2013 study. Rates of deterioration from VT to unshockable rhythms was higher in this study than in the Nehme 2013 study (18.5% and 11.5%, respectively).

One study of witnessed and unwitnessed CA (Pellis 2009) included no patients with witnessed VT and only one patient with unwitnessed VT, and therefore does not contribute to the findings for this population.

For induced VT, cardioversion outcomes after PT were less successful than for patients in CA, with arrhythmia termination rates of 1.5% to 1.9% observed in the larger studies (Haman 2009; Amir 2007). No rhythm deterioration from VT after PT was seen in any patients with induced VT.

4.1.2 PT for ventricular fibrillation

A comparative cohort study of witnessed CA (Nehme 2013) found that patients with VF were significantly less likely to achieve immediate ROSC after PT (3.9%) compared to defibrillation (58.5%; RR 0.07 [0.02, 0.21]), but also significantly less likely to deteriorate to an unshockable rhythm (1.3% versus 12.7%; RR 0.10 [0.01, 0.75]). Rhythm improvement from VF to VT occurred in 2.6% of the PT cohort and none of the defibrillation cohort patients.

In the other two CA studies, the use of PT did not result in immediate ROSC, nor produce a change in rhythm, in any patients with VF. This included a cohort of witnessed CA (Miller 1984; n=23), and a cohort of unwitnessed CA (Pellis 2009; n=22[48]). Similarly, PT did not terminate induced VF in any of the electrophysiology investigation studies.

[48] One additional patient had witnessed VF, but immediate ROSC was not achieved in this patient either.

4.1.3 PT for pulseless electrical activity

In one cohort of unwitnessed CA patients with PEA (Pellis 2009; n=38), PT did not result in immediate ROSC, and rhythm change was observed in only one patient (to asystole; 2.6%). In four witnessed CA patients with PEA, the same study observed no immediate ROSC and no rhythm change.

4.1.4 PT for asystole

Immediate ROSC was achieved with PT in three of six witnessed CA patients with asystole (Pellis 2009). The other three patients remained in asystole. In the same study, PT did not result in immediate ROSC or rhythm change in any of 72 unwitnessed CA patients with asystole. One patient in this cohort (1.4%) experienced a change from asystole to PEA.

4.2 Overall ROSC and survival outcomes in cardiac arrest studies

In a comparative cohort study of witnessed CA (Nehme 2013), no difference was observed in overall ROSC (90%), pulse at hospital arrival (80%) or overall survival (70%) between the PT-first and defibrillation-first cohorts (90%, 80% and 70%, respectively, in both the PT-first and defibrillation-first groups). Substantially lower rates of overall ROSC and survival to discharge were observed in another comparative study (Pellis 2009), but CA was largely unwitnessed. There was no difference in these outcomes, however, between the PT and non-PT cohorts in this study (approximately 20% overall ROSC in both groups, and 6% overall survival in both groups).

4.3 Termination of induced arrhythmias

Among four studies of induced arrhythmias, PT did not result in arrhythmia termination in any cases of VF or ventricular flutter. Only two studies observed termination of induced VT (Haman 2009, 1.5%; Amir 2007, 1.9%). Although a number of spontaneous arrhythmias were terminated in the Volkmann 1990 study, none of the induced arrhythmias were terminated after PT.

4.4 Narrative summary

4.4.1 Comparative evidence – ventricular tachycardia and ventricular fibrillation

Cardiac arrest

One study has shown that PT is less effective than defibrillation at inducing immediate ROSC in witnessed VT and VF (Nehme 2013, N=428). The rate of rhythm deterioration from VT to VF was significantly higher after PT than defibrillation. However, for both VT and VF, defibrillation resulted in higher rates of deterioration to unshockable rhythms (PEA or asystole) compared to PT, with the difference being statistically significant for VT. No difference between groups was seen, however, for the longer term outcomes of overall ROSC and survival to discharge in either study, nor in pulse on hospital arrival in the Nehme 2013 study (not reported in Pellis 2009), indicating the addition of PT to standard care does not compromise these outcomes.

4.4.2 PT cohorts – ventricular tachycardia and ventricular fibrillation

Cardiac arrest

For VT in witnessed CA, two studies have shown that PT results in immediate ROSC in around 7% of patients, and rhythm deterioration in around 30% (Nehme 2013, n=27; Miller 1984, n=27). Rates were lower in patients with VF: 3.9% for immediate ROSC and 1.3% for rhythm deterioration (Nehme 2013,

n=76). The Miller 1984 and Pellis 2009 studies reported no events for either outcome in cases of VF, but VF sample sizes were too small for similar rates to have resulted in any events (n=23 and n=22, respectively).

Induced arrhythmias

In two studies of induced arrhythmia, VT termination after PT was less frequent than observed in studies of CA (1.5% to 1.9%; Haman 2009, n=134; Amir 2007, n=52). In three studies, VF termination was not observed to occur after PT in any patients, although VF cohort sizes were smaller than for VT (Haman 2009, n=21; Amir 2007, n=28; Volkmann n=10, of which 7 had ventricular flutter). No change in rhythm occurred in any patients after PT in any of four studies of induced arrhythmias (Haman 2009, N=155; Amir 2007, N=80; Miller 1985, N=11; Volkmann 1990, n=20).

4.4.3 PT cohorts – unshockable rhythms (pulseless electrical activity and asystole)

Cardiac arrest

One study reported outcomes of PT for unshockable rhythms (Pellis 2009). Sample sizes were small for witnessed PEA (n=4) and asystole (n=6), yet half of the witnessed asystole patients experienced immediate ROSC after PT, two of which survived to discharge (none of the witnessed patients with PEA experienced immediate ROSC after PT nor after standard CPR). Despite this high success rate for witnessed asystole, sample sizes are insufficient to assess the effectiveness of PT in witnessed unshockable rhythms.

Sample sizes were larger for unwitnessed PEA (n=38) and asystole (n=72), yet no patients in either group experienced immediate ROSC after PT (10% and 14% of these patients, respectively, experienced immediate ROSC after standard CPR). Among patients in PEA or asystole, one unwitnessed CA in each group underwent rhythm change to the other unshockable rhythm after PT.

5 Grading of body of evidence

5.1 EVIDENCE PROFILE TABLES

Evidence profile tables are shown for those populations for which comparative evidence was available. Table 5.1 indicates which populations have comparative evidence, by witness status.

Table 5.1 Cardiac arrest populations with comparative evidence for PT

Population	Witnessed	Unwitnessed	Mix of witnessed/unwitnessed (mostly witnessed)
Single arrhythmias			
VT	✓		
VF	✓		
PEA			
asystole			
Mix of arrhythmias			
VT/VF	✓		
VF/PEA/asystole			✓

Abbreviations: PEA, pulseless electrical activity; PT, precordial thump; VF, ventricular fibrillation; VT, ventricular tachycardia

Table 5.2 presents the GRADE evidence profile for PT for patients with monitored OHCA while the population with unmonitored OHCA or a mixture of monitored and unmonitored OHCA is shown in Table 5.3. The evidence for each outcome is shown by cardiac rhythm population.

The highest level of quality attributable to a body of evidence that is based on observational studies is 'low' (GRADE Handbook, Schünemann 2013). As all PT studies are observational, the body of evidence is assumed to be of low quality prior to any subsequent downgrading due to serious limitations identified in any of the five domains of quality assessment (risk of bias, inconsistency, indirectness, imprecision, publication bias).

Table 5.2 GRADE evidence profile: patients with witnessed OHCA

Studies	Study design	Quality assessment: Risk of bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Population: Standard care n/N (%)	Intervention n/N (%)	RR[49] [95% CI]	Anticipated absolute effect: Assumed risk	Absolute risk difference with PT [95% CI]	Quality [a]	Importance
VT/VF – witnessed													
ROSC after first manoeuvre							**witnessed VT/VF**						Important
1[50]	cohort study with control group	Not serious	N/A	Not serious	None	Not suspected	Defibrillation 188/325 (57.8)	PT 5/103 (4.9)	**0.08 [0.04, 0.20]**	578 per 1,000	532 fewer per 1,000 [from 555 fewer to 462 fewer]	●●○○ Low	
Any rhythm deterioration[51]							**witnessed VT/VF**						Limited importance
1[50]	cohort study with control group	Not serious	N/A	Not serious	Serious	Not suspected	Defibrillation 40/325 (12.3)	PT 10/103 (9.7)	0.79 [0.41, 1.52]	123 per 1,000	26 fewer per 1,000 (from 73 fewer to 64 more)	●○○○ Very low[a]	
Deterioration to unshockable rhythm							**witnessed VT/VF**						Limited importance
1[50]	cohort study with control group	Not serious	N/A	Not serious	None	Not suspected	Defibrillation 40/325 (12.3)	PT 2/103 (1.9)	**0.18 [0.04, 0.74]**	123 per 1,000	101 fewer per 1,000 (from 118 fewer to 32 fewer)	●●○○ Low[a]	
ROSC, overall							**witnessed VT/VF**						Critical
1[50]	cohort study with control group	Not serious	N/A	Not serious	None	Not suspected	Defibrillation followed by SC 292/325 (89.8)	PT followed by SC 96/103 (93.2)	1.04 [0.97, 1.11]	898 per 1,000	36 more per 1,000 [from 26 fewer to 99 more]	●●○○ Low[a]	
Survival to hospital							**witnessed VT/VF**						Critical
1[50]	cohort study with control group	Not serious	N/A	Not serious	None	Not suspected	Defibrillation followed by SC 256/325 (78.8)	PT followed by SC 86/103 (83.5)	1.06 [0.96, 1.17]	788 per 1,000	47 more per 1,000 [from 32 fewer to 134 more]	●●○○ Low[a]	
Survival to discharge							**witnessed VT/VF**						Critical
1[50]	cohort study with control group	Not serious	N/A	Not serious	None	Not suspected	Defibrillation followed by SC 228/325 (70.2)	PT followed by SC 73/103 (70.9)	1.01 [0.88, 1.17]	702 per 1,000	7 more per 1,000 [from 85 fewer to 119 more]	●●○○ Low[a]	
VT – witnessed													
ROSC after first manoeuvre							**witnessed VT**						Important
1[50]	cohort study with control group	Not serious	N/A	Not serious	None	Not Suspected	Defibrillation. 54/96 (56.3)	PT 2/27 (7.4)	**0.13 [0.03, 0.51]**	563 per 1,000	490 fewer per 1,000 [from 546 fewer to 276 fewer]	●●○○ Low[a]	
Any rhythm deterioration							**witnessed VT**						Limited importance
1[50]	cohort study with control group	Not serious	N/A	Not serious	Serious	Not Suspected	Defibrillation 11/96 (11.5)	PT 9/27 (33.3)	**2.91 [1.35, 6.29]**	115 per 1,000	220 more per 1,000 (from 40 more to 608 more)	●○○○ Very low[a]	
Deterioration to unshockable rhythm							**witnessed VT**						Limited importance
1[50]	cohort study with control group	Not serious	N/A	Not serious	Serious	NOT Suspected	Defibrillation 11/96 (11.5)	PT 1/27 (3.7)	0.32 [0.04, 2.39]	115 per 1,000	78 fewer per 1,000 (from 110 fewer to 160 more)	●○○○ Very low[a]	

[49] Calculated post hoc from number of events using Review Manager 5.3.
[50] Nehme 2013.
[51] Defined as change from VT to VF or VT/VF to an unshockable rhythm.

Studies	Study design	Quality assessment					Population			Anticipated absolute effect		Quality [a]	Importance
		Risk of bias	Incon-sistency	Indirect-ness	Impreci-sion	Publica-tion Bias	Standard care n/N (%)	Intervention n/N (%)	RR[49] [95% CI]	Assumed risk	Absolute risk difference with PT [95% CI]		
VF – witnessed													
ROSC after first manoeuvre								**witnessed VF**					Important
1[52]	cohort study with control group	Not serious	N/A	Not serious	None	Not suspected	Defibrillation 134/229 (58.5)	PT 3/76 (3.9)	**0.07 [0.02, 0.21]**	585 per 1,000	544 fewer per 1,000 [from 573 fewer to 462 fewer]	●●○○ Low[a]	
Any rhythm deterioration (i.e. unshockable rhythm)								**witnessed VF**					Limited importance
1[52]	cohort study with control group	Not serious	N/A	Not serious	None	Not suspected	Defibrillation 29/229 (12.7)	PT 1/76 (1.3)	**0.10 [0.01, 0.75]**	127 per 1,000	114 fewer per 1,000 (from 126 fewer to 32 fewer)	●●○○ Low[a]	

Footnote: a. The highest-possible quality level for studies of observational design is low.
Abbreviations: CI, confidence interval; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; N/A, not applicable; OHCA, out-of-hospital cardiac arrest; PT, precordial thump; ROSC, return of spontaneous circulation; RR, relative risk; SC, standard care; VF, ventricular fibrillation; VT, ventricular tachycardia.

Table 5.3 GRADE evidence profile: patients with mostly unwitnessed OHCA

Studies	Study design	Quality assessment					Population			Anticipated absolute effect		Quality [a]	Importance
		Risk of bias	Incon-sistency	Indirect-ness	Impreci-sion	Publica-tion Bias	Standard care n/N (%)	Intervention n/N (%)	RR[53] [95% CI]	Assumed risk	Absolute risk difference with PT [95% CI]		
VF/PEA/asystole[54] – witnessed/unwitnessed[55]													
ROSC, overall								**VF/PEA/asystole**					Important
1[56]	cohort study with control group	Not serious	N/A	Not Serious	Serious	Not suspected	Non-PT CPR 43/219 (19.6)	PT followed by SC 31/144 (21.5)	1.10 [0.73, 1.65]	196 per 1,000	20 more per 1,000 [from 53 fewer to 127 more]	●○○○ Very low	
Survival to discharge								**VF/PEA/asystole**					Critical
1[56]	cohort study with control group	Not serious	N/A	Not serious	Serious	Not suspected	Non-PT CPR 14/219 (6.4)	PT followed by SC 8/144 (5.6)	0.87 [0.37, 2.02]	64 per 1,000	8 fewer per 1,000 [from 40 fewer to 65 more]	●○○○ Very low[a]	

Footnote: a. The highest-possible quality level for studies of observational design is low.
Abbreviations: CI, confidence interval; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; N/A, not applicable; OHCA, out-of-hospital cardiac arrest; PEA, pulseless electrical activity; PT, precordial thump; ROSC, return of spontaneous circulation; RR, relative risk; SC, standard care; VF, ventricular fibrillation; VT, ventricular tachycardia.

[52] Nehme 2013
[53] Calculated post hoc from number of events using Review Manager 5.3.
[54] As only one patient across both cohorts in this study had VT, this rhythm is not listed here.
[55] Over 90% unwitnessed.
[56] Pellis 2009

6 Evidence statements

6.1 PT FIRST VERSUS DEFIBRILLATION FIRST FOR WITNESSED CARDIAC ARREST

6.1.1 Ventricular tachycardia and ventricular fibrillation

Table 6.1 Evidence statements – PT for witnessed VT/VF

Population: witnessed VT/VF
Immediate outcomes
ROSC after first manoeuvre
For the important outcome of ROSC after first manoeuvre, we have identified low quality evidence from 1 observational study (Nehme 2013) of 428 patients with monitored VT/VF showing precordial thump is inferior to defibrillation (RR 0.08 [0.04, 0.20]), with the absolute risk decreasing from 58% after defibrillation to 4.6% after PT.
Any rhythm deterioration
For the outcome of any rhythm deterioration, we have identified very low quality evidence from 1 observational study (Nehme 2013) of 428 patients with monitored VT/VF showing no difference between precordial thump and defibrillation (RR 0.79 [0.41, 1.52]).
Deterioration to unshockable rhythm
For the outcome of deterioration to an unshockable rhythm (PEA or asystole), we have identified low quality evidence from 1 observational study (Nehme 2013) of 428 patients with monitored VT/VF showing precordial thump is superior to defibrillation (RR 0.18 [0.04, 0.74]), with the absolute risk decreasing from 12% after defibrillation to 1.9% after PT.
Longer term outcomes
Overall ROSC
For the critical outcome of overall ROSC, we have identified low quality evidence from 1 observational study (Nehme 2013) of 428 patients with monitored VT/VF showing no difference between precordial thump plus standard care and standard care alone (RR 1.04 [0.97, 1.11]).
Survival to hospital
For the critical outcome of survival to hospital, we have identified low quality evidence from 1 observational study (Nehme 2013) of 428 patients with monitored VT/VF showing no difference between precordial thump plus standard care compared to standard care alone (RR 1.06 [0.96, 1.17]).
Survival to hospital discharge
For the critical outcome of survival to discharge, we have identified low quality evidence from 1 observational study (Nehme 2013) of 428 patients with monitored VT/VF showing no difference between precordial thump plus standard care compared to standard care alone (RR 1.01 [0.88, 1.17]).
Neurologically intact survival
No evidence was identified for this outcome in this population.

Abbreviations: PT, precordial thump; ROSC, return of spontaneous circulation; RR, relative risk; VF, ventricular fibrillation; VT, ventricular tachycardia.

Table 6.2 Evidence statements – PT for witnessed VT

Population: witnessed VT
Immediate outcomes
ROSC after first manoeuvre
For the important outcome of ROSC after first manoeuvre, we have identified low quality evidence from 1 observational study (Nehme 2013) of 123 patients with monitored VT showing precordial thump is inferior to defibrillation (RR 0.13 [0.03, 0.51]), with the absolute risk decreasing from 56% after defibrillation to 7.4% after PT.
Any rhythm deterioration
For the outcome of rhythm deterioration, we have identified very low quality evidence from 1 observational study (Nehme 2013) of 123 patients with monitored VT showing precordial thump is inferior to defibrillation (RR 2.91 [1.35, 6.29]), with the risk of rhythm deterioration increasing from 11% after defibrillation to 33% after PT.
Deterioration to unshockable rhythm
For the outcome of deterioration to an unshockable rhythm, we have identified very low quality evidence from 1 observational study (Nehme 2013) of 123 patients with monitored VT showing no difference between precordial thump and defibrillation (RR 0.32 [0.04, 2.39]).
Longer term outcomes
Overall ROSC
No comparative evidence was identified for this outcome in this population.

Population: witnessed VT
Survival to hospital
No evidence was identified for this outcome in this population.
Survival to hospital discharge
No evidence was identified for this outcome in this population.
Neurologically intact survival
No evidence was identified for this outcome in this population.

Abbreviations: PT, precordial thump; ROSC, return of spontaneous circulation; RR, relative risk; VT, ventricular tachycardia.

Table 6.3 Evidence statements – PT for witnessed VF

Population: witnessed VF
Immediate outcomes
ROSC after first manoeuvre
For the important outcome of ROSC after first manoeuvre, we have identified low quality evidence from 1 observational study (Nehme 2013) of 305 patients with monitored VF showing precordial thump is inferior to defibrillation (RR 0.07 [0.02, 0.21]), with the absolute risk decreasing from 58% after defibrillation to 3.9% after PT.
Any rhythm deterioration (i.e. unshockable rhythm)
For the outcome of rhythm deterioration, we have identified low quality evidence from 1 observational study (Nehme 2013) of 305 patients with monitored VF showing precordial thump is superior to defibrillation (RR 0.10 [0.01, 0.75]), with the risk decreasing from 13% after defibrillation to 1.3% after PT.
Longer term outcomes
Overall ROSC
No comparative evidence was identified for this outcome in this population.
Survival to hospital
No evidence was identified for this outcome in this population.
Survival to hospital discharge
No comparative evidence was identified for this outcome in this population.
Neurologically intact survival
No evidence was identified for this outcome in this population.

Abbreviations: PT, precordial thump; ROSC, return of spontaneous circulation; RR, relative risk; VF, ventricular fibrillation.

6.2 PT FIRST VERSUS NO PT FOR WITNESSED OR UNWITNESSED CARDIAC ARREST

6.2.1 Ventricular fibrillation, pulseless electrical activity or asystole

Table 6.4 Evidence statements – PT for VF/PEA/asystole, witnessed/unwitnessed

Population: VF/PEA/asystole
Immediate outcomes
ROSC after first manoeuvre
No comparative evidence was identified for this outcome in this population.
Any rhythm deterioration
No comparative evidence was identified for this outcome in this population.
Deterioration to unshockable rhythm
No comparative evidence was identified for this outcome in this population.
Longer term outcomes
Overall ROSC
For the critical outcome of overall ROSC, we have identified very low quality evidence from 1 observational study (Pellis 2009) of 363 patients with mostly unwitnessed VF/PEA/asystole showing no difference between precordial thump plus standard care and standard care alone (RR 1.10 [0.73, 1.65]).
Survival to hospital
No evidence was identified for this outcome in this population.

Population: VF/PEA/asystole
Survival to hospital discharge *For the critical outcome of survival to discharge, we have identified low quality evidence from 1 observational study (Pellis) of 363 patients with mostly unwitnessed VF/PEA/asystole showing no difference between precordial thump plus standard care compared to standard care alone (RR 0.87 [0.37, 2.02]).*
Neurologically intact survival *No evidence was identified for this outcome in this population.*

Abbreviations: PEA, pulseless electrical activity; PT, precordial thump; ROSC, return of spontaneous circulation; RR, relative risk; VF, ventricular fibrillation.

7 References

Amir O, Schliamser JE, Nemer S, Arie M. (2007). Ineffectiveness of precordial thump for cardioversion of malignant ventricular tachyarrhythmias. PACE - Pacing and Clinical Electrophysiology. 30(2):153-6.

ANZCOR 2011 Guideline 11.3, Precordial thump and fist pacing. Available on the ARC website.

Haman L, Parizek P, Vojacek J. (2009). Precordial thump efficacy in termination of induced ventricular arrhythmias. Resuscitation. 80(1):14-6.

Koster RW, Sayre MR, Botha M, Cave DM, Cudnik MT, Handley AJ, et al. (2010). Part 5: Adult basic life support: 2010 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Resuscitation. 81 Suppl 1:e48-70.

Link MS, Berkow LC, Kudenchuk PJ, Halperin HR, Hess EP, Moitra VK, et al. (2015). Part 7: Adult Advanced Cardiovascular Life Support: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 132(18 Suppl 2):S444-64.

Miller J, Addas A, Akhtar M. (1985). Electrophysiology studies: Precordial thumping patients paced into ventricular tachycardia. Journal of Emergency Medicine. 3(3):175-9.

Miller J, Tresch D, Horwitz L, Thompson BM, Aprahamian C, Darin JC. (1984). The precordial thump. Annals of Emergency Medicine. 13(9 II):791-4.

National Health and Medical Research Council. NHMRC levels of evidence and grades for recommendations for developers of guidelines. Canberra: National Health and Medical Research Council, 2009. Available online.

Nehme Z, Andrew E, Bernard SA, Smith K. (2013). Treatment of monitored out-of-hospital ventricular fibrillation and pulseless ventricular tachycardia utilising the precordial thump. Resuscitation. 84(12):1691-6.

Pellis T, Kette F, Lovisa D, Franceschino E, Magagnin L, Mercante WP, et al. (2009). Utility of pre-cordial thump for treatment of out of hospital cardiac arrest: A prospective study. Resuscitation. 80(1):17-23.

Sayre MR, Koster RW, Botha M, Cave DM, Cudnik MT, Handley AJ, et al. (2010). Part 5: Adult basic life support: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Circulation. 122(16 Suppl 2):S298-324.

Schünemann H, Brożek J, Guyatt G, Oxman A, editors. GRADE handbook for grading quality of evidence and strength of recommendations. Updated October 2013. The GRADE Working Group, 2013. Available from www.guidelinedevelopment.org/handbook.

Soar J, Nolan JP, Bottiger BW, Perkins GD, Lott C, Carli P, et al. (2015+). European Resuscitation Council Guidelines for Resuscitation 2015: Section 3. Adult advanced life support. Resuscitation. 95:100-47.

Volkmann H, Klumbies A, Kuhnert H, Paliege R, Dannberg G, Siegert K. (1990). Termination of ventricular tachycardias by mechanical cardiac pacing by means of precordial thumps. [German]. Zeitschrift fur Kardiologie. 79(10):717-24.

Appendix A EXCLUSION OF RECORDS BY DATABASE

The set of unique records consisted of all unique Embase records, with further unique records added sequentially from Medline, CINAHL, and then the Cochrane Library.

Table AppA.1 Application of inclusion and exclusion criteria to identified records, by contributing database

Description	Embase	Medline	CINAHL	Cochrane	Total
Total records	285	214	4	40	543
Duplicates	10	201	0	2	213
Unique records screened	**275**	**13**	**4**	**38**	**330**
Title/abstract review exclusions:					
Wrong population	*31*	*1*	*0*	*24*	*56*
Wrong intervention	*125*	*3*	*0*	*14*	*142*
Wrong outcomes	*2*	*0*	*0*	*0*	*2*
Wrong study type	*15*	*1*	*1*	*0*	*17*
Wrong publication type	*30*	*4*	*2*	*0*	*36*
Non-English with no English abstract	*4*	*0*	*0*	*0*	*4*
Not in humans	*4*	*0*	*0*	*0*	*4*
Duplicate data	*1*	*0*	*0*	*0*	*1*
Total excluded at title/abstract review	212	9	3	38	262
Total records reviewed at full text	**63**	**4**	**1**	**0**	**68**
Full text review exclusions:					
Wrong population	*3*	*0*	*0*	*0*	*3*
Wrong intervention	*1*	*0*	*0*	*0*	*1*
Wrong outcomes	*2*	*0*	*0*	*0*	*2*
Wrong study type	*30*	*2*	*0*	*0*	*32*
Wrong publication type	*17*	*2*	*1*	*0*	*20*
Not in humans	*3*	*0*	*0*	*0*	*3*
Total excluded at full text review	56	4	1	0	61
Included studies	**7**	**0**	**0**	**0**	**7**

Abbreviations: CINAHL, Cumulative Index to Nursing and Allied Health Literature.

Appendix B EXCLUDED STUDIES

B.1 Studies excluded at full text review

A total of 61 records were excluded at full text review, for the reasons shown in Table AppB.1.

Table AppB.1 Full text review exclusions with reason

Citation	Reason for exclusion
Anonymous. (1971). Chest thump in ventricular tachycardia. Lancet. 1(7697):488.	Wrong publication type – letter
Anonymous. (1971). Chest thumps and the heart beat. The New England journal of medicine. 284(7):392-393.	Wrong publication type – letter
Atmaca M and Mermi O. (2014). A case of ventricular tachycardia and cardiac arrest associated with sertraline and mirtazapine combination. Iranian Journal of Psychiatry. 9(1):45-46.	Wrong study type – case report
Baderman H and Robertson NR. (1965). Thumping the precordium. Lancet. 2(7425):1293.	Wrong publication type – letter
Barold SS. (2000). Atrioventricular block following thumpversion of ventricular tachycardia. PACE - Pacing and Clinical Electrophysiology. 23(11 I):1703-1704.	Wrong study type – case report
Befeler B. (1978). Mechanical stimulation of the heart. Its therapeutic value in tachyarrhythmias. Chest. 73(6):832-8.	Wrong population – not restricted to CA patients and not an electrophysiology study
Bierfeld JL, Rodriguez-Viera V and Aranda JM. (1979). Terminating ventricular fibrillation by chest thump. Angiology. 30(10):703-707.	Wrong study type – case report
Bornemann C and Scherf D. (1969). Electrocardiogram of the month. Paroxysmal ventricular tachycardia abolished by a blow to the precordium. Diseases of the chest. 56(1):83-84.	Wrong study type – case report
Brandenburg JT. (1959). Successful treatment by a chest blow of cardiac arrest during myocardial infarction. JAMA (Chicago, Ill.). 170(11):1307-1308.	Wrong study type – case report
Caldwell G, Millar G and Quinn E. (1985). Simple mechanical methods for cardioversion: Defence of the precordial thump and cough version. British Medical Journal. 291(6496):627-630.	Wrong study type – mix of CA and non-CA patients, with only three CA patients receiving PT (i.e. case reports)
Cavalli A. (1999). Commotio cordis: A precordial thump? [2]. Heart. 82(4):534.	Wrong publication type – letter
Cayla G, Macia JC and Pasquie JL. (2007). Precordial thump in the catheterization laboratory: Experimental evidence for commotio cordis. Circulation. 115(11):e332.	Wrong study type – case report
Cheng TO. (1972). Watch out for those unnecessary thumps and zaps. Rn. 35(12):ICU2.	Wrong publication type – magazine article
Cheng TO. (2006). Bumpversion vs. thumpversion. International Journal of Cardiology. 113(2):247.	Wrong publication type – letter
Chester WL. (1988). Spinal anesthesia, complete heart block, and the precordial chest thump: An unusual complication and a unique resuscitation. Anesthesiology. 69(4):600-602.	Wrong study type – case report
Cotoi S. (1981). Precordial thump and termination of cardiac reentrant tachyarrhythmias. American Heart Journal. 101(5):675-677.	Wrong study type – case report
Cotoi S, Moldovan D, Carasca E. (1980). Precordial thump in the treatment of cardiac arrhythmias (electrophysiologic considerations. Revue Roumaine de Morphologie,d'Embryologie et de Physiologie - Serie Physiologie. 17(4):285-8.	Wrong study type – case reports
Crampton RS, Aldrich RF, Gascho JA, Miles Jr JR and Stillerman R. (1975). Reduction of prehospital, ambulance and community coronary death rates by the community wide emergency cardiac care system. American Journal of Medicine. 58(2):151-165.	Wrong study type – case reports for PT
Davis EY. (1971). Posterior thump-version. The New England journal of medicine. 284(15):919.	Wrong publication type – letter
De Maio VJ, Stiell IG, Spaite DW, Ward RE, Lyver MB, Field BJ, Munkley DP and Wells GA. (2001). CPR-only survivors of out-of-hospital cardiac arrest: Implications for out-of-hospital care and cardiac arrest research methodology. Annals of Emergency Medicine. 37(6):602-608.	Wrong study type – PT only one of multiple interventions investigated, and was applied to a single patient in CA (i.e. case report)
Elliot C and Sandler DA. (2000). The Resuscitation Council (UK) recommends a precordial thump as first treatment of a witnessed or in monitored cardiac arrest. Resuscitation. 47(1):91-92.	Wrong publication type – letter
Faleiro Oliveira J, Rebelo Pacheco S, Moniz M, Nunes P, Abadesso C, Rebelo M, Loureiro H and Almeida H. (2016). Stunned myocardium after an anesthetic procedure in a pediatric patient - case report. Revista Portuguesa de Cardiologia. 35(6):375.e1-375.e5.	Wrong study type – case report
Gertsch M, Hottinger S, Hess T and Shander D. (1992). Serial chest thumps for the treatment of ventricular tachycardia in patients with coronary artery disease [1]. Clinical Cardiology. 15(7):A28.	Wrong intervention – serial chest thump (i.e. pacing) confirmed in full text
Gowda RM, Khan IA, Punukollu G, Vasavada BC, Sacchi TJ and Wilbur SL. (2004). Female preponderance in ibutilide-induced torsade de pointes. International Journal of Cardiology. 95(2-3):219-222.	Wrong population (not necessarily in CA) and also PT used only in two patients (Wrong study type).
Grauhan O, Solowjowa N, Meyer R and Hetzer R. (2009). Postoperative exostosis of the xiphoid process: a contraindication for precordial thump. European Journal of Cardio-thoracic Surgery. 36(3):588.	Wrong study type – case report
Greenberg HB. (1965). Cardiac arrest in 20 infants and children: Causes and results of resuscitation. Diseases of the Chest. 47(1):42-46.	Wrong study type – cohort receiving various interventions, with only 2 patients receiving PT
Jan SL, Fu YC, Lin MC and Hwang B. (2012). Precordial thump in a newborn with refractory supraventricular tachycardia and cardiovascular collapse after amiodarone administration. European Journal of Emergency Medicine. 19(2):128-9.	Wrong study type – case report
Jevon P. (2006). Resuscitation skills - part five: precordial thump. Nursing times. 102(29):28-29.	Wrong publication type – review

Khan AS. (1977). Management of cardiac arrest: seven steps to survival. Canadian Medical Association Journal. 117(2):162-165.	Wrong publication type – review
Kimura Y, Hoshi K, Inoue T, Takayanagi K, Asahi S, Kase M, Fujito T, Hayashi T, Kamishirado H, Morooka S and et al. (1992). [A case of angina pectoris with cardiac arrest at treadmill stress test]. Kokyu to Junkan - Respiration & Circulation. 40(7):721-4.	Wrong study type – case report
Kracoff OH, Singer Y and Gueron M. (1987). Chest thump terminating atrioventricular nodal reentry tachycardia. American Heart Journal. 114(4 I):904-905.	Wrong study type – case report
Krijne R. (1984). Rate acceleration of ventricular tachycardia after a precordial chest thump. American Journal of Cardiology. 53(7):964-965.	Wrong study type – case report
Kwast HA. (1971). "Endocardial thump". The New England journal of medicine. 284(14):795.	Wrong publication type – letter
Lederer W, Wiedermann FJ, Cerchiari E and Baubin MA. (1999). Electricity-associated injuries. I: Outdoor management of current-induced casualties. Resuscitation. 43(1):69-77.	Wrong publication type – review
Lown B. (2009). The antiarrhythmic blow to the sternum: Thumpversion. Heart Rhythm. 6(10):1512-1513.	Wrong publication type – review
Lown B and Taylor J. (1970). "Thump-version". New England Journal of Medicine. 283(22):1223-4.	Wrong publication type – editorial
Madias C, Maron BJ, Alsheikh-Ali AA, Rajab M, Estes INAM and Link MS. (2009). Precordial thump for cardiac arrest is effective for asystole but not for ventricular fibrillation. Heart Rhythm. 6(10):1495-1500.	Not in humans – animal study
Morgera T, Baldi N, Chersevani D, Medugno G and Camerini F. (1979). Chest thump and ventricular tachycardia. PACE - Pacing and Clinical Electrophysiology. 2(1):69-75.	Wrong population – patients in VT but CA status not reported in full text.
Ohkado S, Kobayashi Y, Homma Y, Fukuda K, Abe K, Sakurai S, Sugiyama A, Ichinohe T and Kaneko Y. (1998). Systemic medical complications triggered by conscious sedation. [Japanese]. Journal of Japanese Dental Society of Anesthesiology. 26(2):259-263.	Wrong study type – case report
Patros RJ, Goren CC. (1983). The precordial thump: An adjunct to emergency medicine. Heart and Lung: Journal of Acute and Critical Care. 12(1):61-4.	Wrong study type – case reports
Pawar SC, Patil SS, Jagtap SR and Deolokar S. (2009). Cardiac arrest after submucosal infiltration with lignocaine 2% - Epinephrine in nasal surgery: A case report. Southern African Journal of Anaesthesia and Analgesia. 15(5):29-31.	Wrong study type – case report
Pellis T, Pausler D, Gaiarin M, Franceschino E, Epstein A, Boulin C and Kohl P. (2012). Off-patient assessment of pre-cordial impact mechanics among medical professionals in North-East Italy involved in emergency cardiac resuscitation. Progress in Biophysics and Molecular Biology. 110(2-3):390-396.	Wrong outcomes – technical characteristics of PT
Pennington JE, Taylor J and Lown B. (1970). Chest thump for reverting ventricular tachycardia. The New England journal of medicine. 283(22):1192-1195.	Wrong study type – case report
Petsas AA, Pinto R and Kotler MN. (1973). Sudden and unexpected ventricular standstill in acute myocardial infarction. Chest. 63(3):386-390.	Wrong study type – case report
Pride YB, Frost EJ, Anderson PD and Cutlip DE. (2011). Precordial steering wheel: A fortunate accident. Journal of Emergency Medicine. 41(4):e83-e87.	Wrong study type – case report
Rajagopalan RS, Appu KS, Sultan SK, Jagannadhan TG, Nityanandan K, Sethuraman S. (1971). Precordial thump in ventricular tachycardia. The Journal of the Association of Physicians of India. 19(10):725-9.	Wrong study type – case reports
Robertson C. (1992). The precordial thump and cough techniques in advanced life support. Resuscitation. 24(2):133-135.	Wrong publication type – ERC position statement
Sabiston WR and Hicks JN. (1982). Office and operating room management of cardiac arrest. Archives of Otolaryngology. 108(2):87-89.	Wrong publication type – BLS instructions
Santilli RA, Diana A and Baron Toaldo M. (2012). Orthodromic atrioventricular reciprocating tachycardia conducted with intraventricular conduction disturbance mimicking ventricular tachycardia in an English Bulldog. Journal of Veterinary Cardiology. 14(2):363-370.	Not in humans – animal study
Sclarovsky S. (1985). Chest thump acceleration of ventricular tachycardia. The American journal of cardiology. 55(1):249.	Wrong publication type – letter
Sclarovsky S, Kracoff O and Arditi A. (1982). Ventricular tachycardia 'pleomorphism' induced by chest thump. Chest. 81(1):97-98.	Wrong study type – case report
Sclarovsky S, Kracoff OH and Agmon J. (1981). Acceleration of ventricular tachycardia induced by a chest thump. Chest. 80(5):596-599.	Wrong study type – case report
Sorensen M, Engbek J and Viby-Mogensen J. (1984). Bradycardia and cardiac asystole following a single injection of suxamethonium. Acta Anaesthesiologica Scandinavica. 28(2):232-235.	Wrong study type – case report
Van Cleef ANH, Schuurman MJ and Busari JO. (2011). Third-degree atrioventricular block in an adolescent following acute alcohol intoxication. BMJ Case Reports.	Wrong study type – case report
Wesley K. (2014). Ineffectiveness of the precordial thump. Outdated practice doesn't save lives. JEMS: a journal of emergency medical services. 39(10):25.	Wrong publication type – commentary
Wesley K and Wesley K. (2014). STREET SCIENCE. INEFFECTIVENESS OF THE PRECORDIAL THUMP. JEMS: Journal of Emergency Medical Services. 39(10):25-25.	Wrong publication type – review/column
Westin J, Songer P, Buchanan K, Gorosh L, Hodnick R and Bledsoe BE. (2012). Miracle in the desert. Cardiac case at remote burning man event presents challenges. JEMS: a journal of emergency medical services. 37(5):32-33, 35.	Wrong study type – case report
Wong MP and Armstrong PW. (1999). Supraventricular tachycardia terminated by external mechanical stimulation: A case of 'pothole conversion'. PACE - Pacing and Clinical Electrophysiology. 22(2):376-378.	Wrong study type – case report
Xiangqian S, Yanhua Z, Min D, Ying X, Wei M, Shibing Z, Xiaojie Z and Jinyu H. (2014). Influencing factors of the success rate of cardiopulmonary resuscitation. Journal of the American College of Cardiology. 1):C240.	Wrong outcomes – no quantitative data for PT (also wrong publication type – conference abstract)

Yakaitis RW and Redding JS. (1973). Precordial thumping during cardiac resuscitation. Critical care medicine. 1(1):22-26.	Not in humans – animal study
Zurcher KA. (1972). Thump pacing and thump version. Lancet. 1(7742):144.	Wrong publication type – letter

B.2 Studies excluded based on presumptions regarding population or study design

Three studies for which the full text article was not readily available were excluded despite insufficient information for unequivocal exclusion (Table AppB.2**)**. None were included in the 2010 ILCOR CoSTR, and they were presumed not to be relevant clinical studies (allocated to wrong study design i.e. likely to be a review article).

Table AppB.2 Studies excluded based on presumptions regarding population or study design

Studies excluded without full text and unclear inclusion/exclusion status
Doelp R, Ahnefeld FW, Dick W. (1974). The cardio pulmonary resuscitation methodic variation. [German]. Anaesthesist. 23(10):450-2.
Michael TAD. (1965). Precordial percussion in cardiac resuscitation. Amer. Heart J. 69(5):721-2.
Packard JM. (1977). To thump or not to thump? Journal of the Medical Association of the State of Alabama. 47(5):10-2.

Appendix C EVIDENCE HIERARCHY

The levels of evidence hierarchy developed by the NHMRC is shown in Table AppC.1.These levels of evidence were used, with minor clarifications as described in the main Evidence Review report, to classify eligible studies prior to inclusion in the Review.

Table AppC.1 Designations of levels of evidence for interventional studies

Level	Intervention
I[a]	A systematic review of Level II studies
II	A randomised controlled trial
III-1	A pseudo-randomised controlled trial (i.e. alternate allocation or some other method)
III-2	A comparative study with concurrent controls: • Non-randomised, experimental trial[b] • Cohort study • Case-control study • Interrupted time series with a control group
III-3	A comparative study without concurrent controls: • Historical control study • Two or more single-arm study[c] • Interrupted time series without a parallel control group
IV	Case series with either post-test or pre-test/post-test outcomes

Source: National Health and Medical Research Council. NHMRC levels of evidence and grades for recommendations for developers of guidelines. Canberra: National Health and Medical Research Council, 2009. Available online.

a systematic review will only be assigned a level of evidence as high as the studies it contains, excepting where those studies are of Level II evidence. Systematic reviews of Level II evidence provide more data than the individual studies and any meta-analyses will increase the precision of the overall results, reducing the likelihood that the results are affected by chance. Systematic reviews of lower level evidence present results of likely poor internal validity and thus are rated on the likelihood that the results have been affected by bias, rather than whether the systematic review itself is of good quality. Systematic review quality should be assessed separately. A systematic review should consist of at least two studies. In systematic reviews that include different study designs, the overall level of evidence should relate to each individual outcome/result, as different studies (and study designs) might contribute to each different outcome.

b This also includes controlled before-and-after (pre-test/post-test) studies, as well as adjusted indirect comparisons (i.e. utilise A vs B and B vs C, to determine A vs C with statistical adjustment for B).

c Comparing single-arm studies i.e. case series from two studies. This would also include unadjusted indirect comparisons (i.e. utilise A vs B and B vs C, to determine A vs C but where there is no statistical adjustment for B).

Appendix D ADDITIONAL DATA EXTRACTION

Table AppD.1 Interventions used to treat arrhythmias during EP investigations – Volkmann 1990

Arrhythmia number	Patients with >1 arrhythmia	PT attempts	Maximum no. of PTs per attempt	Interpretation of PT interventions received	Successful cardioversion method
VF					
B1[57]		3	1	3 attempts each with a single PT	defibrillation
B2		3	1	3 attempts each with a single PT	defibrillation
B3	also B12	3	4	3 attempts with final attempt = rapid burst of 4 PTs	defibrillation
V-flutter					
B4		3	2	3 attempts with final attempt = rapid burst of 2 PTs	defibrillation
B5		3	1	3 attempts each with a single PT	defibrillation
B6		4	5	4 attempts with final attempt = rapid burst of 5 PTs	defibrillation
B7		2	1	2 attempts each with a single PT	defibrillation
B8		5	7	5 attempts with final attempt = rapid burst of 7 PTs	defibrillation
B9		10	1	10 attempts each with a single PT[58]	defibrillation
B10		4	3	4 attempts with final attempt = rapid burst of 3 PTs	defibrillation
VT					
A3		2	3	2 attempts with final attempt = rapid burst of 3 PTs	rapid burst of 3 PTs
A9[59]		2	2	2 attempts with final attempt = rapid burst of 2 PTs	rapid burst of 2 PTs
A12		3	4	3 attempts with final attempt = rapid burst of 4 PTs	rapid burst of 4 PTs
B11		1	3	1 attempt = rapid burst of 3 PTs[58]	RVS
B12	also B5	1	3	1 attempt = rapid burst of 3 PTs[58]	defibrillation
B13	also B14	6	7	6 attempts with final attempt = rapid burst of 7 PTs	RVS after lidocain
B14	also B13	3	2	3 attempts with final attempt = rapid burst of 2 PTs	defibrillation
B15		5	6	5 attempts with final attempt = rapid burst of 6 PTs	RVS
B19		1	5	1 attempt = rapid burst of 3 PTs[58]	RVS
B25		4	8	4 attempts with final attempt = rapid burst of 8 PTs	defibrillation

Abbreviations: PT. precordial thump, RVS, right ventricular stimulation.

Note: Arrhythmias labelled with an A were successfully cardioverted by the application of PT while those labelled with B were not.

[57] This patient was undergoing pacemaker implantation.

[58] The authors of the current Review note that this intervention pattern is outside that described in the methodology, which prescribed up to three individual PT manoeuvres before using rapid bursts of PT.

[59] This patient also experienced a spontaneous arrhythmia, which was successfully converted with PT after two attempts, the with final being a rapid burst of 3 PTs. This data is excluded from extraction in this Review as it is not an induced arrhythmia.

Appendix E RISK OF BIAS OF INCLUDED STUDIES

E.1 Primary question studies

Risk-of-bias assessment for Nehme 2013

SIGN	Scottish Intercollegiate Guidelines Network – Methodology Checklist 3 for Cohort Studies **Study type:** retrospective controlled cohort study				Nehme 2013 **Reviewer:** JR
Guideline topic: precordial thump	**Key Question No:** Primary	**Yes**	**Un-clear**	**No**	**N/A**
SECTION **1: INTERNAL VALIDITY**					
1.1	The study addresses an appropriate and clearly focused question. *'… we assessed the efficacy of the PT …/… in patients with monitored out-of-hospital VT/VF …'*	✓			
Selection of Subjects					
1.2	The two groups being studied are selected from source populations that are comparable in all respects other than the factor under investigation. *Demographic information presented for sex, age, cardiac rhythm, time to first manoeuvre, time from arrival on scene to cardiac arrest, and number of arrest (no significant differences between groups).*	✓			
1.3	The study indicates how many of the people asked[60] to take part did so, in each of the groups being studied. *132/1379 OHCA cases had missing records. Apart from that, all eligible patients were included in the study.*	✓			
1.4	The likelihood that some eligible subjects might have the outcome at the time of enrolment is assessed and taken into account in the analysis.				†
1.5	What percentage of individuals or clusters recruited into each arm of the study dropped out before the study was completed. *Outcomes were reported for all included patients.*	0%			
1.6	Comparison is made between full participants and those lost to follow up, by exposure status.				†
Assessment					
1.7	The outcomes are clearly defined.	✓			
1.8	The assessment of outcome is made blind to exposure status. If the study is retrospective this may not be applicable.				†
1.9	Where blinding was not possible, there is some recognition that knowledge of exposure status could have influenced the assessment of outcome. *Not likely to cause bias as ROSC and survival outcomes are unequivocal, and rhythm change outcomes are unlikely to be subject to bias.*			✓	
1.10	The method of assessment of exposure is reliable.	✓			
1.11	Evidence from other sources is used to demonstrate that the method of outcome assessment is valid and reliable.				†
1.12	Exposure level or prognostic factor is assessed more than once. *However, reporting of events by EMS personnel is likely to be reliable: 'Electronically captured clinical data are synchronised daily with an organisational clinical database. The VACAR identifies potential OHCA cases using a highly sensitive database search strategy, and screens individual cases for eligibility. Review of computer-aided dispatch records supplements the identification of potential cases. In the absence of electronically completed records, paramedic team managers are required to identify and submit eligible paper records to the VACAR for screening. This process is further supplemented with the screening of all paper records received by the finance and billing department. Eligible OHCA cases are reviewed and entered into the registry according to the Utstein requirements.'*			✓	
Confounding					
1.13	The main potential confounders are identified and taken into account in the design and analysis. *No confounders were accounted for in analysis. However, as the intervention is used in critical situations, it is not feasible to triage cases beyond vital signs and cardiac rhythm for appropriate populations. Furthermore, main confounder may be the experience of the attending EMS personnel rather than any patient characteristics.*			✓	
Statistical analysis					
1.14	Have confidence intervals been provided?	✓			

[60] Even though patients were not asked, this pertains to the completeness of the set of included patients.

SIGN	**Scottish Intercollegiate Guidelines Network – Methodology Checklist 3 for Cohort Studies**				**Nehme 2013**
	Study type: retrospective controlled cohort study				**Reviewer:** JR
Guideline topic: precordial thump	**Key Question No:** Primary	**Yes**	**Un-clear**	**No**	**N/A**
SECTION 2: OVERALL ASSESSMENT OF THE STUDY					
2.1	How well was the study done to minimise the risk of bias or confounding? *Within the limits of an observational study this risk of bias is low. The administration of PT is likely to be impacted by personal preferences and the degree of expertise/confidence of the attending EMS personnel. But this intervention allocation is not necessarily related to patient selection, so is not a concerning source of bias.*	✓	High quality (++) Acceptable (+) Unacceptable: reject (0)		
2.2	Taking into account clinical considerations, your evaluation of the methodology used, and the statistical power of the study, do you think there is clear evidence of an association between exposure and outcome?	✓			
2.3	Are the results of this study directly applicable to the patient group targeted in this guideline?	✓			
2.4	**Notes.** Summarise the authors conclusions. Add any comments on your own assessment of the study, and the extent to which it answers your question and mention any areas of uncertainty raised above. *Authors' conclusion: The PT used as first-line treatment of monitored VT/VF rarely results in ROSC, and is more often associated with rhythm deterioration. Support for its use in patients with monitored episodes of VT/VF should be re-examined. What remains unclear is whether the use of a PT is of greater benefit than immediate chest compressions in circumstances where defibrillation is not possible within the first few minutes of arrest. With the extensive use of defibrillators in most clinical settings, the need to resolve this uncertainty with further prospective studies is becoming less relevant.* *Reviewer's comments: Highest quality study of PT for cardiac arrest, well reported with little risk of bias beyond that attributable to study type (retrospective with non-randomised treatment allocation).*				
Source of funding: not reported. **Conflict of interest:** none declared.					

Note: Adapted from the SIGN Methodology Checklist 3 for cohort studies.
Abbreviations: EMS, emergency medical service; N/A, not applicable; OHCA, out-of-hospital cardiac arrest; PT, precordial thump; ROSC, return of spontaneous circulation; VACAR, Victorian Ambulance Cardiac Arrest Registry; VF, ventricular fibrillation; VT, ventricular tachycardia; SIGN, Scottish Intercollegiate Guidelines Network.
†Question is not applicable to the population, intervention, outcome or study design.

Risk-of-bias assessment for Pellis 2009

SIGN	**Scottish Intercollegiate Guidelines Network – Methodology Checklist 3 for Cohort Studies**				**Pellis 2009**
	Study type: prospective cohort study with concurrent control group for limited outcomes				**Reviewer: JR**
Guideline topic: precordial thump	**Key Question No:** Primary	**Yes**	**Un-clear**	**No**	**N/A**
SECTION 1: INTERNAL VALIDITY					
1.1	The study addresses an appropriate and clearly focused question. *'… no prospective data on the utility of PT in OHCA has been reported. Accordingly we decided to evaluate the effects of PT in a prospective fashion in the OHCA setting.'*	✓			
Selection of Subjects					
1.2	The two groups being studied are selected from source populations that are comparable in all respects other than the factor under investigation. *Demographic information was presented for sex, age, cardiac rhythm, time to first manoeuvre, EMS-witness status and bystander CPR (significantly different for the latter).*		✓		
1.3	The study indicates how many of the people asked[61] to take part did so, in each of the groups being studied. *All eligible patients were included in the study. 144/363 eligible patients received PT protocol while those that did not formed the comparator group.*	✓			
1.4	The likelihood that some eligible subjects might have the outcome at the time of enrolment is assessed and taken into account in the analysis.				†
1.5	What percentage of individuals or clusters recruited into each arm of the study dropped out before the study was completed. *All patients that received PT had outcomes reported. Patients that received non-PT protocol had main outcomes reported, but the focus of this study was the PT cohort.*	0%			
1.6	Comparison is made between full participants and those lost to follow up, by exposure status.				†
Assessment					
1.7	The outcomes are clearly defined.	✓			
1.8	The assessment of outcome is made blind to exposure status. If the study is retrospective this may not be applicable.			✓	

[61] Even though patients were not asked, this pertains to the completeness of the set of included patients.

SIGN	**Scottish Intercollegiate Guidelines Network – Methodology Checklist 3 for Cohort Studies**				**Pellis 2009**
	Study type: prospective cohort study with concurrent control group for limited outcomes				**Reviewer: JR**
Guideline topic: precordial thump	**Key Question No:** Primary	**Yes**	**Un-clear**	**No**	**N/A**
1.9	Where blinding was not possible, there is some recognition that knowledge of exposure status could have influenced the assessment of outcome. *Not likely to cause bias as ROSC and survival outcomes are unequivocal, and rhythm change outcomes are unlikely to be subject to bias.*			✓	
1.10	The method of assessment of exposure is reliable.	✓			
1.11	Evidence from other sources is used to demonstrate that the method of outcome assessment is valid and reliable.				†
1.12	Exposure level or prognostic factor is assessed more than once. *However, reporting of events by EMS personnel is likely to be reliable: 'all CPR and CA data are reported according to the Utstein style'.*			✓	
Confounding					
1.13	The main potential confounders are identified and taken into account in the design and analysis. *No confounders were accounted for in analysis. However, as the intervention is used in critical situations, it is not feasible to triage cases beyond vital signs and cardiac rhythm for appropriate populations. Furthermore, main confounder may be the experience of the attending EMS personnel rather than any patient characteristics*			✓	
Statistical analysis					
1.14	Have confidence intervals been provided? *Descriptive statistics are reported, and where differences between groups are statistically significant, this is indicated as p<0.05*			✓	
SECTION 2: OVERALL ASSESSMENT OF THE STUDY					
2.1	How well was the study done to minimise the risk of bias or confounding? *All eligible patients were supposed to receive PT first, but only 144/363 eligible patients did (incomplete protocol adherence). Patients receiving protocol treatment were compared with those not receiving protocol treatment. Therefore, unexplained treatment allocation is a source of possible bias.* *The decision to use PT is likely to be impacted by personal preferences and the degree of experience or confidence of the attending EMS personnel. Therefore, the incomplete PT protocol adherence may pertain to EMS personnel characteristics rather than patient characteristics, and is not considered a concerning source of bias.*	✓	High quality (++) Acceptable (+) Unacceptable: reject (0)		
2.2	Taking into account clinical considerations, your evaluation of the methodology used, and the statistical power of the study, do you think there is clear evidence of an association between exposure and outcome? *No clear evidence of an association between PT and resuscitation in cardiac rhythm subgroups, but there is clear evidence of the frequent ineffectiveness of PT when applied to unwitnessed CA with any cardiac rhythm.*			✓	
2.3	Are the results of this study directly applicable to the patient group targeted in this guideline?		✓		
2.4	**Notes.** Summarise the authors conclusions. Add any comments on your own assessment of the study, and the extent to which it answers your question and mention any areas of uncertainty raised above.				

Source of funding: No commercial sponsors were involved in study design, data collection, analysis, interpretation, and writing of the report. Peter Kohl is supported by the UK Medical Research Council and the British Heart Foundation.

Conflict of interest: The authors declared no conflict of interest

Note: Adapted from the SIGN Methodology Checklist 3 for cohort studies.

Abbreviations: CA, cardiac arrest; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; N/A, not applicable OHCA, out-of-hospital cardiac arrest; PEA, pulseless electrical activity; PT, precordial thump; ROSC, return of spontaneous circulation; SIGN, Scottish Intercollegiate Guidelines Network; VF, ventricular fibrillation; VT, ventricular tachycardia.

†Question is not applicable to the population, intervention, outcome or study design.

Risk-of-bias assessment for Miller 1984

JBI	**The Joanna Briggs Institute critical appraisal tools – Checklist for case series**				**Miller 1984**
	Study type: retrospective single cohort study/case series				
Guideline topic: precordial thump		**Key Question No:** Primary	**Reviewer:** JR		
No.	**Question**	**Yes**	**Unclear**	**No**	**N/A**
1	Were there clear criteria for inclusion in the case series? *'Fifty patients receiving precordial thumps from July 1982 through February 1983 during in-field paramedic resuscitations have been studied.'* *There is no indication of whether this is all patients that received PT during this period or a subset of PT recipients (e.g. those with records); nor is the reason for using PT described.*			✓	
2	Was the condition measured in a standard, reliable way for all participants included in the case series?	✓			
3	Were valid methods used for identification of the condition for all participants included in the case series?	✓			
4	Did the case series have consecutive inclusion of participants?		✓		
5	Did the case series have complete inclusion of participants?		✓		
6	Was there clear reporting of the demographics of the participants in the study? *Age range only.*			✓	
7	Was there clear reporting of clinical information of the participants? *Presenting rhythm only.*			✓	
8	Were the outcomes or follow up results of cases clearly reported?	✓			
9	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	✓			
10	Was statistical analysis appropriate?				✓
Overall appraisal		✓ Include __ Exclude __ Seek further info			
Author's conclusion: Our study demonstrates that in the prehospital setting, the precordial thump is usually not beneficial and may actually be detrimental. The use of the precordial thump as the initial manoeuvre in treating the cardiac arrest patient with monitored ventricular tachycardia or ventricular fibrillation in the prehospital setting is not recommended.					
Reviewer's comments: Acceptable quality study, with limitations regarding unclear definition of eligible cohort and retrospective design.					
Source of funding: Not reported. **Conflict of interest:** Not reported.					

Note: Adapted from the Critical Appraisal Checklist for Case Series, Joanna Briggs Institute, 2016.
Abbreviations: N/A, not applicable; PT, precordial thump.

E.2 Supplementary question studies

Risk-of-bias assessment for Haman 2009

JBI	**The Joanna Briggs Institute critical appraisal tools – Checklist for case series** **Study type:** prospective single cohort study/consecutive case series				**Haman 2009**
Guideline topic: precordial thump		**Key Question No:** Suppl.	**Reviewer:** JR		
No.	**Question**	**Yes**	**Unclear**	**No**	**N/A**
1	Were there clear criteria for inclusion in the case series?	✓			
2	Was the condition measured in a standard, reliable way for all participants included in the case series?	✓			
3	Were valid methods used for identification of the condition for all participants included in the case series?	✓			
4	Did the case series have consecutive inclusion of participants?	✓			
5	Did the case series have complete inclusion of participants?	✓			
6	Was there clear reporting of the demographics of the participants in the study?	✓			
7	Was there clear reporting of clinical information of the participants?	✓			
8	Were the outcomes or follow up results of cases clearly reported?	✓			
9	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	✓			
10	Was statistical analysis appropriate?				✓
Overall appraisal		✓ Include __ Exclude __ Seek further info			
Author's conclusion: The efficacy of PT for termination of induced non-tolerated ventricular tachyarrhythmias is very low even with application early after the onset of arrhythmia. Our study provides new evidence about this safe but generally non-productive manoeuvre, which may inform future revisions of cardiopulmonary resuscitation guidelines.					
Reviewer's comments: Acceptable quality study with clear reporting of exclusion criteria, identifying a complete cohort of consecutive eligible patients with induced arrhythmia.					
Source of funding: Not reported. **Conflict of interest:** "None declared".					

Note: adapted from the Critical Appraisal Checklist for Case Series, Joanna Briggs Institute, 2016.
Abbreviations: N/A, not applicable; PT, precordial thump.

Risk-of-bias assessment for Amir 2007

JBI	**The Joanna Briggs Institute critical appraisal tools – Checklist for case series** **Study type:** study design				**Amir 2007**
Guideline topic: precordial thump		**Key Question No:** Suppl.	**Reviewer:JR**		
No.	**Question**	**Yes**	**Unclear**	**No**	**N/A**
1	Were there clear criteria for inclusion in the case series?	✓			
2	Was the condition measured in a standard, reliable way for all participants included in the case series?	✓			
3	Were valid methods used for identification of the condition for all participants included in the case series?	✓			
4	Did the case series have consecutive inclusion of participants?	✓			
5	Did the case series have complete inclusion of participants? *"The study included 80 consecutive patients who agreed to participate in the study." This statement is ambiguous – either (i) all eligible patients agreed to participate, or (ii) only a subset of those asked actually participated (i.e. those who agreed).*		✓		
6	Was there clear reporting of the demographics of the participants in the study?	✓			
7	Was there clear reporting of clinical information of the participants?	✓			
8	Were the outcomes or follow up results of cases clearly reported?	✓			
9	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	✓			
10	Was statistical analysis appropriate?				✓
Overall appraisal		✓ Include __ Exclude __ Seek further info			
Author's conclusion: PT is not effective in terminating malignant ventricular tachyarrhythmia and should be reserved to situations in which a defibrillator is not available.					
Reviewer's comments: Acceptable quality study of what appears to be a complete cohort of consecutive eligible patients with induced arrhythmia.					
Source of funding: Not reported. **Conflict of interest:** Not reported.					

Note: Adapted from the Critical Appraisal Checklist for Case Series, Joanna Briggs Institute, 2016.
Abbreviations: N/A, not applicable; PT, precordial thump.

Risk-of-bias assessment for Volkmann 1990

JBI	The Joanna Briggs Institute critical appraisal tools – Checklist for case series				Volkmann 1990
	Study type: prospective single cohort study/consecutive case series				
Guideline topic: precordial thump		**Key Question No:** Suppl.	**Reviewer:** JR		
No.	**Question**	**Yes**	**Unclear**	**No**	**N/A**
1	Were there clear criteria for inclusion in the case series?	✓			
2	Was the condition measured in a standard, reliable way for all participants included in the case series?	✓			
3	Were valid methods used for identification of the condition for all participants included in the case series?	✓			
4	Did the case series have consecutive inclusion of participants?	✓			
5	Did the case series have complete inclusion of participants?	✓			
6	Was there clear reporting of the demographics of the participants in the study?	✓			
7	Was there clear reporting of clinical information of the participants?	✓			
8	Were the outcomes or follow up results of cases clearly reported?	✓			
9	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	✓			
10	Was statistical analysis appropriate?				✓
Overall appraisal		✓ Include __ Exclude __ Seek further info			

Author's conclusion: Under certain conditions (medical experience, access to defibrillation), PT can expand the range of therapeutic options for ventricular tachycardias. In patients with ventricular fibrillation and flutter, the chances of success are only minimal. As a "blind measure" PT is useless, dangerous and therefore to be avoided.

Reviewer's comments: Acceptable quality study of what appears to be a complete cohort of consecutive eligible patients with induced arrhythmia and/or non-induced (spontaneous) arrhythmia. Results reported per arrhythmia, allowing extraction of data for induced arrhythmias. Overall findings for all arrhythmias are also reported (e.g. more success with lower tachycardia rates) but are not relevant to this Evidence Review due to the mixed population.

Source of funding: Not reported.
Conflict of interest: Not reported.

Note: Adapted from the Critical Appraisal Checklist for Case Series, Joanna Briggs Institute, 2016.
Abbreviations: N/A, not applicable; PT, precordial thump.

Risk-of-bias assessment for Miller 1985

JBI	The Joanna Briggs Institute critical appraisal tools – Checklist for case series				Miller 1985
	Study type: prospective case series				
Guideline topic: precordial thump		**Key Question No:** Suppl.	**Reviewer:** JR		
No.	**Question**	**Yes**	**Unclear**	**No**	**N/A**
1	Were there clear criteria for inclusion in the case series?	✓			
2	Was the condition measured in a standard, reliable way for all participants included in the case series?	✓			
3	Were valid methods used for identification of the condition for all participants included in the case series?	✓			
4	Did the case series have consecutive inclusion of participants?		✓		
5	Did the case series have complete inclusion of participants?		✓		
6	Was there clear reporting of the demographics of the participants in the study?			✓	
7	Was there clear reporting of clinical information of the participants?	✓			
8	Were the outcomes or follow up results of cases clearly reported?	✓			
9	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?			✓	
10	Was statistical analysis appropriate?				✓
Overall appraisal		✓ Include __ Exclude __ Seek further info			

Author's conclusion: 'we would conclude that cardioversion is more effective than PT for ventricular tachycardia. Previously reported "detrimental" effects of precordial thumping (not confirmed by this study) are possibly related to the overall poor prognosis of prehospital cardiac arrest patients.'

Reviewer's comments: Unclear whether this sample is representative, location of setting not described and demographics not reported (could justify exclusion).

Source of funding: Not reported.
Conflict of interest: Not reported.

Note: Adapted from the Critical Appraisal Checklist for Case Series, Joanna Briggs Institute, 2016.
Abbreviations: N/A, not applicable; PT, precordial thump.

Appendix F CONCORDANCE WITH PRIOR ILCOR CONSENSUS ON SCIENCE

The 2010 ILCOR Consensus on Science statement for PT is shown in Table AppF.1, with citations and study details listed. Statements are made for particular arrhythmic populations (VF, VT, asystole) and in various settings (in the EP laboratory, in- or out-of-hospital). However, in contrast to the current Evidence Review, studies of induced arrhythmias where CA status is not reported are regarded as CA studies (e.g. Amir 2007, and Volkmann 1990 in the statement for in- and out-of-hospital VF CA).

Table AppF.1 2010 ILCOR Consensus on Science statement for PT, shown with referenced studies and population

Population described in CoS	Consensus on Science statement	Study ID	In current Review?	Study population
VF, in- and out-of-hospital, cardiac arrest	In five prospective case series of out-of-hospital (LOE 4)			
		Pellis 2009	yes	CA
		Amir 2007	yes	EP-induced
		Volkmann 1990	yes	EP-induced & spontaneous (reported sep.)
		Caldwell 1985	no	mixed CA & non-CA (not EP)
		Miller 1984	yes	CA
	and two series (LOE 4) of in-hospital VF cardiac arrest,			
		Amir 2007	yes	EP-induced
		Volkmann 1990	yes	EP-induced & spontaneous (reported sep.)
	healthcare provider administration of the precordial thump did not result in ROSC.			
VT, in EP laboratory	In three prospective case series of VT in the electrophysiology laboratory (LOE 4)			
		Amir 2007	yes	EP-induced
		Haman 2009	yes	EP-induced
		Miller 1985	yes	EP-induced
	administration of the precordial thump by experienced cardiologists was of limited use (1.3% ROSC).			
VT, not in EP laboratory	When events occurred outside of the electrophysiology laboratory, in six case series of in- and out-of-hospital VT (LOE 4),			
		Volkmann 1990	yes	EP-induced & spontaneous (reported sep.)
		Caldwell 1985	no	mixed CA & non-CA (not EP)
		Miller 1984	yes	CA
		Morgera 1979	no	not CA or EP
		Nejima 1991	no	not CA or EP
		Befeler 1978	no	mixed ward & EP (CA status NR)
	the precordial thump was followed by ROSC in 19% of patients.			
	Rhythm deterioration following precordial thump occurred in 3% of patients and was observed predominantly in patients with prolonged ischaemia or digitalis-induced toxicity.			
Asystolic arrest	In three case series of asystolic arrest (LOE 4)			
		Pellis 2009	yes	CA
		Caldwell 1985	no	mixed CA & non-CA (not EP)
		Cotol 1980	no	not EP (CA status NR)
	the precordial thump, but not fist pacing, was sometimes successful in promoting ROSC when administered by healthcare providers to patients with witnessed asystole (some clearly p-wave asystolic arrest) for OHCA and in-hospital cardiac arrest.			

Population described in CoS	Consensus on Science statement	Study ID	In current Review?	Study population
Adverse events in any patients	Two case series (LOE 4)			
		Miller 1984	yes	CA
		Muller 1992	no	not CA or EP
	and a case report (LOE 5)			
		Ahmar 2007	no	CA
	documented the potential for complications from use of the precordial thump, including sternal fracture, osteomyelitis, stroke, and rhythm deterioration in adults and children.			

Source: Koster 2010, pg. e52

Abbreviations: CA, cardiac arrest; CoS, Consensus on Science; EP, electrophysiology; ILCOR, International Liaison Committee on Resuscitation; LOE, Level of evidence; NR, not reported; OHCA, out-of-hospital cardiac arrest; PT, precordial thump; ROSC, return of spontaneous circulation; VF, ventricular fibrillation; VT, ventricular tachycardia.

Note: studies not included in the current Evidence Review are shown in grey text.