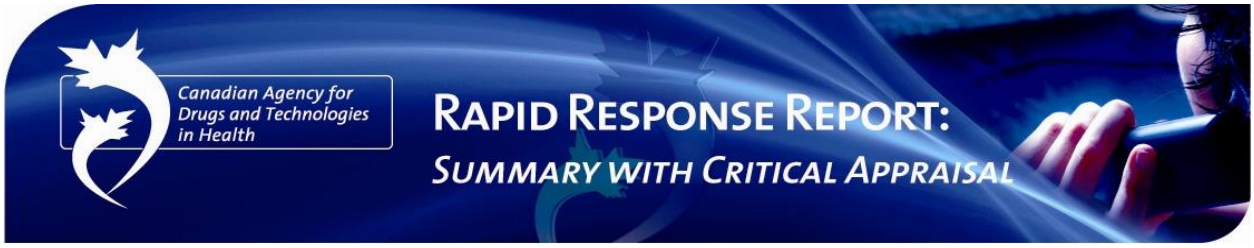

TITLE: **Cardiopulmonary Resuscitation Feedback Devices for Adult Patients in Cardiac Arrest: A Review of Clinical Effectiveness and Guidelines**

DATE: 20 April 2015

CONTEXT AND POLICY ISSUES

The incidence of sudden cardiac arrest in North America and Europe has been estimated to be between 50 to 100 per 100,000 in general population.[1] Immediate initiation of cardiopulmonary resuscitation (CPR) and early defibrillation are keys to survival from sudden cardiac arrest.[1] CPR is comprised of external chest compressions and mouth-to-mouth ventilation.[1] Despite the development of CPR and other advanced resuscitation techniques, the survival rates from sudden cardiac arrest remain low; 1 to 6 percent in the out-of-hospital setting.[1] The rates of survival-to-hospital discharge from out-of-hospital cardiac arrest range from 5 to 10 percent.[1] Low-quality CPR performance is one of the factors contributing to poor survival outcomes.[2] Five key components of high quality CPR include minimizing interruptions in chest compressions, providing adequate rate and depth of compression, avoiding leaning on chest between compressions, and avoiding excessive ventilation.[2] Current technology incorporated into a CPR device such as a defibrillator can provide real-time audiovisual feedback, thus enhancing CPR performance to more closely with guidelines.[3] Studies have shown that real-time feedback devices used in both training and medical settings could improve CPR quality by providing information about the quality of CPR components such as chest compression rate and depth, chest compression fraction, and ventilation rate.[2,4] However, it was unclear if CPR quality improved by such devices could translate into improving survival in humans.

The aim of this report is to review the clinical effectiveness and guidelines regarding the use of CPR feedback devices for adult patients in cardiac arrest.

RESEARCH QUESTIONS

1. What is the clinical effectiveness of CPR feedback devices when used during CPR for adult patients in cardiac arrest?
2. What are the evidence-based guidelines regarding the use of CPR feedback devices during CPR for adult patients in cardiac arrest?

KEY FINDINGS

Current evidence suggests that the use of a CPR feedback device could improve CPR quality, which may not translate into improved patient outcomes. The identified guideline recommends the use of CPR prompt/feedback devices to improve the quality of CPR. No Canadian guidelines were identified.

METHODS

Literature Search Strategy

A limited literature search was conducted on key resources including PubMed, The Cochrane Library (2015, Issue 3), University of York Centre for Reviews and Dissemination (CRD) databases, ECRI, Canadian and major international health technology agencies, as well as a focused Internet search. No filters were applied to limit the retrieval by study type. Where possible, retrieval was limited to the human population. The search was also limited to English language documents published between January 1, 2005 and March 23, 2015.

Selection Criteria and Methods

One reviewer screened the titles and abstracts of the retrieved publications and evaluated the full-text publications for the final article selection, according to selection criteria presented in Table 1.

Table 1: Selection Criteria

Population	Adult patients in cardiac arrest
Intervention	CPR feedback devices (e.g., CPRMeter [Philips])
Comparator	No CPR feedback device, other CPR feedback devices
Outcomes	Clinical benefits and harms, impact on mortality, guidelines
Study Designs	Health technology assessments, systematic reviews, meta-analyses, randomized controlled trials, non-randomized studies, and guidelines

Exclusion Criteria

Studies were excluded if they did not satisfy the selection criteria in Table 1, if they were published prior to 2005, duplicate publications of the same study, or included in a selected health technology assessment or systematic review.

Critical Appraisal of Individual Studies

The quality of systematic review was assessed using AMSTAR.[5] Non-randomized study quality was evaluated using the Downs and Black instrument.[6] The Appraisal of Guidelines Research & Evaluation (AGREE II) instrument was used to evaluate the quality of the included guideline.[7]

For the critical appraisal of studies, a numeric score was not calculated. Instead, the strength and limitations of the studies were described.

SUMMARY OF EVIDENCE

Quantity of Research Available

The literature search yielded 274 citations. Upon screening titles and abstracts, 17 potential relevant articles were retrieved for full-text review. Four additional relevant reports were retrieved from other sources. Of the 21 potentially relevant articles, 3 reports were included in this review including 1 systematic review and meta-analysis, 1 observational study (retrospective, before-after study), and 1 guideline. The study selection process is outlined in a PRISMA flowchart (Appendix 1).

Summary of Study Characteristics

The characteristics of the systematic review and meta-analysis[8] and the observational study[9] are summarized in Appendix 2. Appendix 3 presents the grading of recommendations and levels of evidence of the included guideline.[10]

The systematic review and meta-analysis by Kirkbright et al. (2014)[11] assessed the role of audiovisual feedback devices in improving CPR quality performed by health care practitioners or survival outcomes following cardiac arrest. Evidence was searched in major databases in May 2013 with no publication date or language restrictions. The participants were either manikins to address CPR quality (manikin studies) or humans experiencing cardiac arrest to address both CPR quality and survival (human studies). The setting was either in-hospital or out-of-hospital for CPR given to humans. Studies having real-time use of a CPR device that detects chest wall movement and quantifies rate and depth of chest compressions were included. In human studies, the device was Laerdal QCPR. The comparison group was CPR performed without the use of the device. The primary outcome was survival to hospital discharge with good neurologic outcome. Secondary outcomes included other patient survival data (i.e. rate of return of spontaneous circulation, alive on arrival to emergency department) and quality of CPR performance.

The observational study by Bobrow et al. (2013)[11] was a before-after study of consecutive adult having cardiac arrest in an out-of-hospital setting. Data were retrospectively reviewed in two phases. Phase 1 comprised of 18 months (October 2008 to March 2010) without an audiovisual CPR feedback device, and phase 2 included 16 months (May 2010 to September 2011) following scenario-based training of 373 professionals rescuers and real-time audiovisual feedback devices. The training in phase 2 *"included 2 hours of didactic teaching, along with 2 hours of team-centered psychomotor practice using scenario-based training, and activation of real-time audiovisual feedback. Didactic education and scenario-based training repeatedly and explicitly emphasized a team approach to resuscitation and meticulous compliance with the parameters of high-quality CPR within their minimally interrupted cardiac resuscitation protocol*."[11] The device was the E series Defibrillator Display with Real-Time Audiovisual Feedback Enabled (Zoll Corporation, Chelmsford MA). The outcomes included survival to hospital discharge, favorable functional outcome (Cerebral Performance Category score of 1 or 2), and CPR quality.

One evidence-based guideline (Australian Resuscitation Council and New Zealand Resuscitation Council Guideline 2010[10]) was identified. There were no Canadian guidelines that met the selection criteria. The included guideline provides recommendations on equipment and techniques in adult advanced life support including CPR. The methodology of guideline development and evaluation of the science were described. Recommendations were graded according to the strength of the recommendation and quality of the supporting evidence (Appendix 3).

Summary of Critical Appraisal

The strengths and limitations of the systematic review and meta-analysis[11] and the observational study[9] are summarized in Appendix 4. Those of the guideline[10] are presented in Appendix 5.

The methodological quality of the systematic review and meta-analysis[11] was excellent, as all the items of the AMSTAR checklist were met. These include design, duplicate study selection and data extraction, comprehensive literature search, status of publication (no restriction on publication date or language), list of included and excluded studies, characteristics of included studies, quality assessment of included studies, appropriate meta-analysis, assessment of publication bias, and conflict of interest statement.

The quality of the observational study[9] was limited in reporting (i.e., the characteristics of patients lost to follow-up were not reported, adverse events were not reported), internal validity – bias (i.e., no blinding), internal validity – confounding (i.e., patients were not recruited over the same period of time, no randomization), and power (i.e., lack of power calculation for primary outcome).

The included guideline[10] clearly stated the scope and purpose, stakeholder involvement, rigour of development, and applicability based on the AGREE II instrument. The scientific evidence was rigorously and systematically reviewed by a multidisciplinary panel consisting of representatives of all relevant groups. The level, quality, relevance or strength of the evidence was assessed before formulating recommendations. However, the guideline appears to have limitations in editorial independence, as it is unclear if the views of the funding body have influenced in the content of the guideline, and the competing interest of the guideline development group members have not been recorded and addressed.

Summary of Findings

A. Clinical studies

The main findings and authors' conclusions of the systematic review and meta-analysis[11] and the observational study[9] are presented in Appendix 6.

The systematic review and meta-analysis by Kirkbright et al. 2014[11] included three human studies (N = 2100) and 17 manikin studies. This report focusses on the results from the human studies only. In all three human studies, there were no statistically significant differences between with and without real-time use of CPR feedback device in any patient outcomes including survival to hospital discharge and return of spontaneous circulation. Meta-analytic results showed that the odds ratio (95% CI) for survival to hospital discharge was 0.93 (0.70 to 1.23), and the odds ratio (95% CI) for return of spontaneous circulation was 1.04 (0.87 to 1.24). The I^2 value for both outcomes was 0%, suggesting there was no statistical heterogeneity among studies. CPR quality, on the other hand, was statistically significantly better with real-time use of CPR feedback device as shown in improvement in chest compression depth by 2.5 mm (95% CI 0.9 to 4.3), decrease in mean chest compression rate by more than 6 per minute (95% CI 2.4 to 10.7), and decrease in no-flow fraction by 1.9% (95% CI 1.8 to 2.0). There was substantial heterogeneity among studies for chest compression depth and chest compression rate (I^2 > 70%). It was concluded that there was no evidence that the improvement in CPR quality in real-time use of CPR feedback device translates into improved patient outcomes.

The observational study by Bobrow et al. 2013[9] compared the effect of scenario-based training and real-time audiovisual feedback CPR (phase 2) with no real-time audiovisual feedback CPR (phase 1) in survival, favorable functional outcome, and CPR quality. Survival was 8.7%

(20/231) in phase 1 compared to 13.9% (35/252) in phase 2. The absolute difference (95% CI) was 5.2% (-0.4 to 10.8). The adjusted odds ratio (95% CI) was 2.72 (1.15 to 6.41), which was controlled for witnessed arrest, initial rhythm, provision of therapeutic hypothermia, age, and minimally interrupted cardiac resuscitation protocol compliance. Similarly, the favorable functional outcomes (Cerebral Performance Category score of 1 or 2) as measured at hospital discharge by trained hospital personnel was also improved in phase 2 (10.8% versus 6.5%); the adjusted odds ratio (95% CI) was 2.69 (1.04 to 6.94). CPR quality outcomes including chest compression depth and chest compression rate were also improved in phase 2. It was concluded that the combination of scenario-based training and real-time audiovisual feedback CPR was associated with improved CPR quality and patient outcomes including survival and favorable functional outcomes.

B. Guidelines

The Australian Resuscitation Council and New Zealand Resuscitation Council Guideline 2010[10] had one recommendation statement on the use CPR feedback device (Appendix 7)

- *"CPR prompt / feedback devices may be considered for clinical use as part of an overall strategy to improve the quality of CPR. (**Class B; Level III-2**)"*[10]

  ***Class B: Acceptable** – given to those guidelines which may be beneficial and are acceptable to be used if considered appropriate in that setting*

  ***Level III-2:** Evidence obtained from comparative studies with concurrent controls and allocation not randomized (cohort studies), case control studies, or interrupted time series with a control group.*

Limitations

The systematic review and meta-analysis[11] included only three human studies. There was substantial statistical and clinical heterogeneity among studies with respect to CPR quality outcomes. Although only one type of CPR feedback device (Laerdal QCPR) was used in all three studies, health care practitioners who performed CPR might differ in clinical experience. In addition, different CPR guidelines might be applied in different studies. Outcome reporting might be different among studies. However, there was no heterogeneity with respect to patient outcomes, suggesting that different clinical experience of health care practitioners and the use of real-time feedback device had little influence on the patient outcomes.

The observational study[9] had several limitations. First, it was not randomized. The study was of before-after observational study design, which may introduce confounders that led to improved survival and favorable functional outcomes in the phase 2. Second, data were collected from a single emergency medical services agency with the use of one type of CPR measurement and feedback device. The external validity and reproducibility of the results therefore remain unclear. Third, it was unclear if the improvement in patient outcomes in phase 2 resulted from the influence of scenario-based training, CPR feedback device, or the combination of both interventions. Therefore, the results of the study did not conclusively address the research question as whether or not the use of CPR feedback device improves patient outcomes.

The Australian Resuscitation Council and New Zealand Resuscitation Council Guideline 2010[10] had no apparent limitations, except an update version may be needed to better reflect the current evidence. The guideline acknowledged that there was no evidence suggesting improved patient outcomes with CPR prompt/feedback devices. There are no Canadian guidelines that could be identified in this search period.

CONCLUSIONS AND IMPLICATIONS FOR DECISION OR POLICY MAKING

One systematic review and meta-analysis, one observational before-after study, and one guideline were retrieved. Results from the systematic review suggest that there was no evidence that the use of audiovisual CPR feedback device in either in-hospital or out-of-hospital cardiac arrest could improve patient outcomes. A low quality observational study found that the implementation of resuscitation training combined with real-time audiovisual CPR feedback device was associated with increased patient outcomes. However, the role of CPR feedback device in improving patient outcomes was unclear since scenario-based training was a component of the intervention. The guideline recommended the use of CPR feedback devices to improve the quality of CPR, although it acknowledged that there are no studies demonstrating that CPR feedback devices could improve patient outcomes. No Canadian guidelines were identified.

Taken together, current evidence suggests that the use of CPR feedback device could improve CPR quality, which may not translate into improved patient outcomes.

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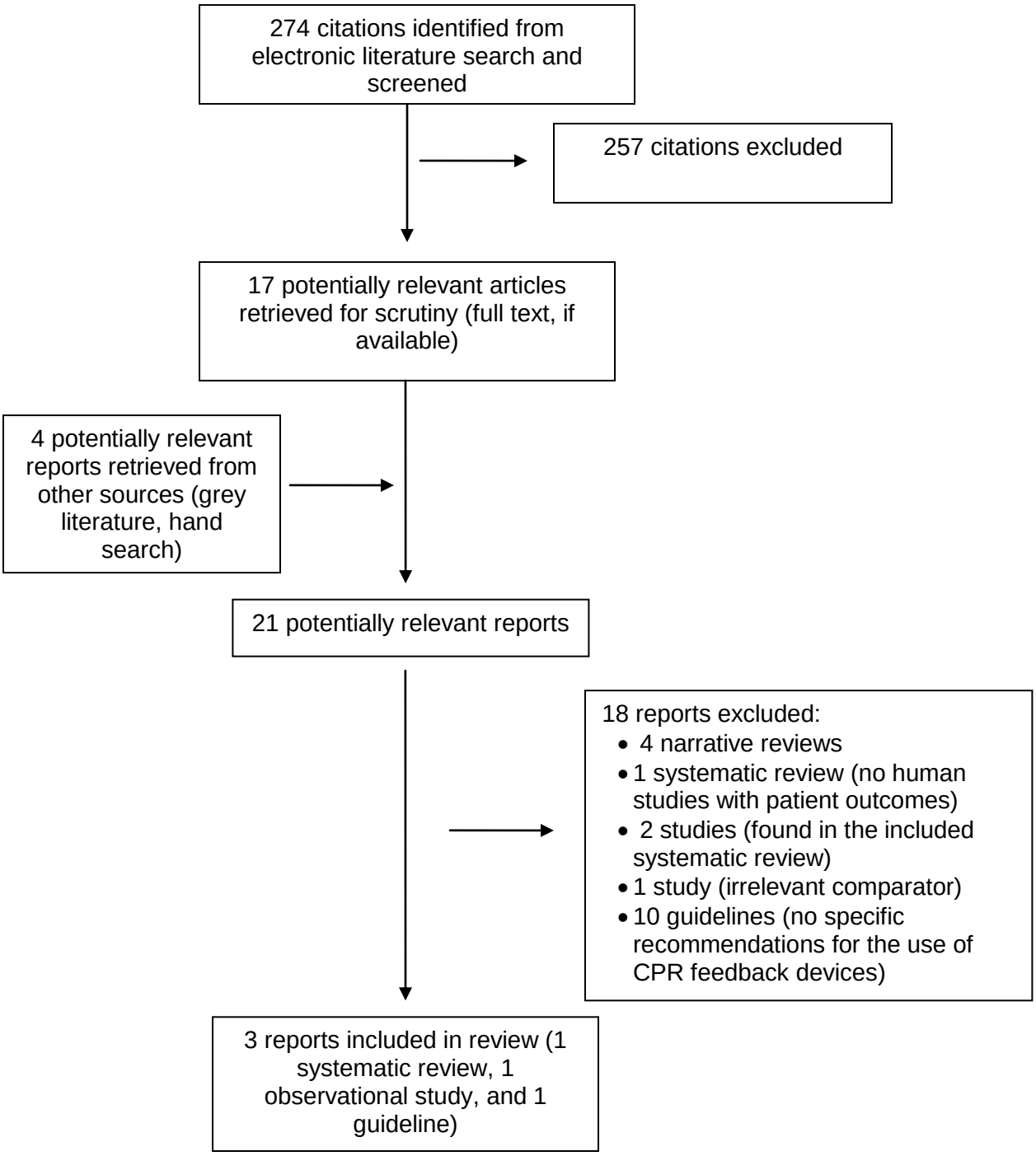
APPENDIX 1: Selection of Included Studies



APPENDIX 2: Characteristics of Included Clinical Studies

First Author, Publication Year, Country	Study Design, Length of Follow-up	Patient characteristics, sample Size (n)	Intervention	Comparators	Clinical Outcomes
Kirkbright et al. 2014[11] Australia	SR and MA	3 human interventional studies (n=2100) • 1 cluster RCT • 2 retrospective control studies Mean age: 62.3 to 68.0 years Male: 49.5% to 75% Mean duration of cardiac arrest prior to EMS arrival: 5.5 to 8 minutes	Real-time use of CPR feedback device [Laerdal Q-CPR feedback device or a prototype of the same device]	Without real-time CPR feedback	1° outcome: Survival to hospital discharge with good neurologic outcome 2° outcomes: • Other survival data • Quality of CPR performance
Bobrow et al. 2013[9]	Before-after study Phase 1: 18 months Phase 2: 16 months	Phase 1: 232 OHCA patients Phase 2: 252 OHCA patients Median age: 68 years Male: 66.5%	Scenario-based training and real-time audiovisual feedback (E series defibrillator with real-time audiovisual feedback enabled [Zoll Corporation, Chelmsford MA]) on OHCA CPR	Without real-time audiovisual CPR feedback	• Survival to hospital discharge • Favorable functional outcome (Cerebral Performance Category score of 1 or 2) • CPR quality

CPR = cardiopulmonary resuscitation; EMS = emergency medical services; IHCA = in-hospital cardiac arrest; MA = meta-analysis; OHCA = out-of-hospital cardiac arrest; RCT = randomized controlled trial; SR = systematic review

APPENDIX 3: Grading of Recommendations and Levels of Evidence

Guideline Society or Institute	Recommendation	Level of Evidence
Australian Resuscitation Council and New Zealand Resuscitation Council Guideline 2010[10]	**Class A: Recommended** – given to those guidelines which are considered to be beneficial and should be used. **Class B: Acceptable** – given to those guidelines which may be beneficial and are acceptable to be used if considered appropriate in that setting.	**Level I:** Evidence obtained from a systematic review of all relevant randomized controlled trials. **Level II:** Evidence obtained from at least one properly designed randomized controlled trial. **Level III-1:** Evidence obtained from well designed pseudo-randomized controlled trials (alternate allocation or other method). **Level III-2:** Evidence obtained from comparative studies with concurrent controls and allocation not randomized (cohort studies), case control studies, or interrupted time series with a control group. **Level III-3:** Evidence obtained from comparative studies with historical control, two or more single arm studies, or interrupted time series without a parallel control group. **Level IV:** Evidence obtained from case series, either post-test or pre-test and post-test.

APPENDIX 4: Summary of Study Strengths and Limitations

Author, year, type of study, country, design	Strengths	and Limitations
Kirkbright et al. 2014[11] Australia SR and MA	• The methodological quality of this systematic review was excellent as all questions of the AMSTAR checklist scored "Yes"	• No limitations
AMSTAR check list 1. Was an "a priori" design provided? 2. Was there duplicate study selection and data extraction? 3. Was a comprehensive literature search performed? 4. Was the status of publication (i.e., grey literature) used as an inclusion criteria? 5. Was a list of studies (included and excluded) provided? 6. Were the characteristics of the included studies provided? 7. Was the scientific quality of the included studies assessed and documented? 8. Was the scientific quality of the included studies used appropriately in formulating conclusions? 9. Were the methods used to combine the findings of studies appropriate? 10. Was the likelihood of publication bias assessed? 11. Was the conflict of interest stated?		
Bobrow et al. 2013[9] USA Retrospective, before-after study	*Reporting* • The objective was clearly described • The main outcome measures were clearly described • The baseline characteristics of the patients included in the study were described • Actual probability values were reported *Internal validity - bias* • Follow-up was the same for all participants *Internal validity – confounding* • Patients in different intervention groups were recruited from the same population *External validity* • The participants were representative of the entire population from which they were recruited	*Reporting* • The characteristics of patients lost to follow-up were not described • Adverse events were not reported *Internal validity – bias* • Attempt was not made to blind those measuring the main outcomes of the intervention *Internal validity – confounding* • Patients in different intervention groups were not recruited over the same period of time • Patients were not randomized to intervention groups *Power* • A power calculation was not reported for the primary outcome • The study did not have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%

APPENDIX 5: Summary of Study Strengths and Limitations – Guidelines

First Author, Publication Year	Strengths	Limitations
Australian Resuscitation Council and New Zealand Resuscitation Council Guideline 2010[10]	Scope and purpose • Objectives and target patients population were explicit • The health question covered by the guidelines is specifically described • The population to whom the guidelines is meant to apply is specifically described Stakeholder involvement • The guideline development group includes individuals from all relevant professional groups • The views and preferences of the target population have been sought • The target users of the guideline are clearly defined Rigour of development • Systematic methods were used to search for evidence • The criteria for selecting the evidence are clearly described • The strengths and limitations of the body of evidence are clearly described • The methods of formulating the recommendations are clearly described • The health benefits, side effects, and risks have been considered in formulating the recommendations • There is an explicit link between the recommendations and the supporting evidence • The guideline has been externally reviewed by experts prior to its publication • A procedure for updating the guideline is provided Applicability • The guidelines provides advice and/or tools on how the recommendations can be put into practice • The guideline describes facilitators and barriers to its application • The potential resource implications of applying the recommendations have been considered • The guideline presents monitoring	Editorial independence • It is unclear if the views of the funding body have influenced the content of the guideline • Competing interests of guideline development group members have not been recorded and addressed

First Author, Publication Year	Strengths	Limitations
	and/or auditing criteria <u>Clarity of recommendation</u> • The recommendations are specific and unambiguous • The different options for management of the condition or health issue are clearly presented • Key recommendations are easily identified	

APPENDIX 6: Main Study Findings and Authors' Conclusions – Clinical

Author, year, type of study, country, design	Condition / Interventions	Results
Kirkbright et al. 2014[11] Australia SR and MA	OHCA and IHCA patients Real-time use of CPR feedback device (Laerdal QCPR) versus no real-time CPR feedback	Survival to hospital discharge: • OR (95% CI) = 0.93 (0.70, 1.23) Return of spontaneous circulation: • OR (95% CI) = 1.04 (0.87, 1.24) CPR quality when used feedback devices: • Chest compression depth: increased by 2.5 mm (95% CI 0.9 to 4.3) • Mean chest compression rate: decreased by more than 6 per minute (95% CI 2.4 to 10.7) • No-flow fraction: decreased by 1.9% (95% CI 1.8 to 2.0)
Authors' conclusions: *"In both manikin and human studies, feedback during resuscitation can result in rescuers providing chest compression parameters closer to recommendations. There is no evidence that this translates into improved patient outcomes."* p 460		
Bobrow et al. 2013[9] USA Retrospective, before-after study	OHCA patients Scenario-based training and real-time audiovisual feedback CPR (E series defibrillator with real-time audiovisual feedback enabled [Zoll Corporation, Chelmsford MA]) versus no real-time audiovisual feedback CPR	Survival: • Phase 1: 8.7% (20/231) vs Phase 2: 13.9% (35/252) • Absolute difference (95% CI) = 5.2 (-0.4 to 10.8) • Crude OR (95% CI) = 1.73 (0.93 to 3.21) • Adjusted OR (95% CI) = 2.72 (1.15 to 6.41) [controlling for witnessed arrest, initial rhythm, provision of therapeutic hypothermia, age, and minimally interrupted cardiac resuscitation protocol compliance] Favorable functional outcomes (CPC score = 1 or 2): • Phase 1: 6.5% (15/230) vs Phase 2: 10.8% (27/251) • Absolute difference (95% CI) = 4.2 (-0.8 to 9.2) • Crude OR (95% CI) = 1.76 (0.88 to 3.52) • Adjusted OR (95% CI) = 2.69 (1.04 to 6.94) [controlling for witnessed arrest, provision of therapeutic hypothermia, age, and minimally interrupted cardiac resuscitation protocol compliance] CPR quality when used training and feedback devices: • Chest compression depth: increased by 0.38 inches (95% CI 0.28 to 0.47) • Mean chest compression rate: decreased by 23 per minute (95% CI 19 to 26)
Authors' conclusions: *"Implementation of resuscitation training combined with real-time audiovisual feedback was independently associated with improved CPR quality, an increase in survival, and favorable functioning outcomes after out-of-hospital cardiac arrest."* p 47		

CI = confidence interval; CPC = Cerebral Performance Category; CPR = cardiopulmonary resuscitation; IHCA = in-hospital cardiac arrest; MA = meta-analysis; OHCA = out-of-hospital cardiac arrest; OR = odds ratio; SR = systematic review

APPENDIX 7: Summary of Guideline Recommendations

Guideline Society, Country, Author, Year	Recommendations
Australian Resuscitation Council and New Zealand Resuscitation Council Guideline 2010[10]	• *CPR prompt / feedback devices may be considered for clinical use as part of an overall strategy to improve the quality of CPR.* (**Class B; Level III-2**) p.289
CPR = Cardiopulmonary resuscitation	