RIASE
REVISTA IBERO-AMERICANA DE SAÚDE E ENVELHECIMENTO
REVISTA IBERO-AMERICANA DE SALUD Y ENVEJECIMIENTO

THE BENEFITS OF CHEST COMPRESSION DEVICES: AN INTEGRATIVE LITERATURE REVIEW

AS VANTAGENS DOS DISPOSITIVOS DE COMPRESSÃO TORÁCICA: UMA REVISÃO INTEGRATIVA DA LITERATURA

LOS BENEFICIOS DE LOS DISPOSITIVOS DE COMPRESIÓN TORÁCICA: UNA REVISIÓN INTEGRATIVA DE LA LITERATURA

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Received/Recebido: 2023-01-13 Accepted/Aceite: 2023-03-28 Published/Publicado: 2023-06-23

DOI: http://dx.doi.org/10.60468/r.riase.2023.9(2).587.117-135

VOL. 9 NO. 2 APRIL 2023

ABSTRACT

Introduction: Cardiac arrest is the leading cause of morbidity and mortality globally. The survival rate of a patient in cardiac arrest decreases dramatically over time, so there should be a rapid and appropriate intervention, applying chest compressions continuously, which can be manual or performed through mechanical devices. The objective of this study is to present the advantages of using mechanical chest compression devices.

Methodology: For the present article, an Integrative Literature Review was developed, using the following MeSH and key words: ((“cardiopulmonary resuscitation”) AND (“heart arrest”) AND (“heart massage”)) and their corresponding terms in Portuguese in the PubMed, Cochrane Central and CINAHL databases.

Results: After applying the inclusion and exclusion criteria, 8 articles were included in this review. After analyzing these articles, several advantages of mechanical chest compression devices were found, including consistency of compression depth, optimal compression rate, no fatigue for the rescuer, perfect functioning both at stationary and transport levels, faster recovery of spontaneous circulation, and prevention of transmission of communicable diseases between patient and health care worker.

Conclusion: Despite scientific advances, cardiac arrests still have a high mortality rate, and the speed and quality of intervention are essential for patient survival. Mechanical chest compression devices are emerging as an effective means of improving the quality of care, especially in the most difficult situations.

Keywords: Cardiopulmonary Resuscitation; Heart Arrest; Heart Massage; Mechanical Chest Compression.

RESUMO

Introdução: A paragem cardíaca é a principal causa de morbilidade e mortalidade em termos globais. A taxa de sobrevivência de um paciente em situação de paragem cardíaca desce drasticamente com o passar do tempo, pelo que deve haver uma intervenção rápida e adequada, aplicando-se, de forma contínua, compressões torácicas, podendo ser manuais ou realizadas através de dispositivos mecânicos. Neste artigo o objetivo é apresentar quais as vantagens da utilização de dispositivos mecânicos de compressão torácica.

Metodologia: Para o presente artigo desenvolveu-se uma Revisão Integrativa da Literatura, realizando-se uma pesquisa com os seguintes termos MeSH e chave de pesquisa: ((“*cardiopulmonary resuscitation*”) AND (“*heart arrest*”) AND (“*heart massage*”)) e seus correspondes-

tes em português nas bases de dados PubMed, Cochrane Central e CINAHL, obtendo-se um total de 208 artigos, tendo sido submetidos para leitura do texto integral, 13 artigos.

Resultados: Incluíram-se 8 artigos na presente revisão, identificando-se as seguintes vantagens dos dispositivos mecânicos de compreensão torácica onde se incluem a consistência da profundidade de compressão, taxa de compressão ótima, não é cansativo para o socorrista, funciona perfeitamente tanto ao nível estacionário como em transporte, permite uma recuperação mais rápida da circulação espontânea e previne a transmissão de doenças.

Conclusão: Apesar dos avanços científicos, a paragem cardíaca continua a ter elevadas taxas de mortalidade, sendo que a rapidez e a qualidade de intervenção é essencial para a sobrevivência dos pacientes. Os dispositivos mecânicos de compressão torácica aparecem como meios eficazes para melhorar a qualidade de assistência, especialmente em situações onde esta é mais difícil.

Palavras-chave: Compressão Torácica Mecânica; Massagem Cardíaca; Paragem cardíaca; Reanimação Cardiopulmonar.

RESUMEN

Introducción: La parada cardíaca es la principal causa de morbilidad y mortalidad en todo el mundo. La tasa de supervivencia de un paciente en parada cardíaca disminuye drásticamente con el paso del tiempo, por lo que debe haber una intervención rápida y adecuada, aplicando compresiones torácicas de forma continua, que pueden ser manuales o realizadas a través de dispositivos mecánicos. El objetivo de este estudio es presentar los beneficios de utilizar dispositivos mecánicos de compresión torácica.

Metodología: Para este artículo se desarrolló una Revisión Integrativa de la Literatura, utilizando los siguientes MeSH y palabras clave: ((*"cardiopulmonary resuscitation"*) AND (*"heart arrest"*) AND (*"heart massage"*)) y sus correspondientes términos en portugués en las bases de datos PubMed, Cochrane Central y CINAHL.

Resultados: Después de aplicar los criterios de inclusión y exclusión, se incluyeron 8 artículos en esta revisión. Después de analizar estos artículos, se encontraron varias ventajas de los dispositivos mecánicos de compresión torácica, como una profundidad de compresión consistente, una tasa de compresión óptima, la ausencia de fatiga para el reanimador, un funcionamiento perfecto tanto en el nivel estacionario como en el de transporte, una recuperación más rápida de la circulación espontánea y la prevención de la transmisión de enfermedades contagiosas entre el paciente y el profesional sanitario.

Conclusión: A pesar de los avances científicos, las paradas cardíacas siguen teniendo una alta tasa de mortalidad, y la rapidez y la calidad de la intervención son esenciales para la

supervivencia del paciente. Los dispositivos mecánicos de compresión torácica se perfilan como un medio eficaz para mejorar la calidad de los cuidados, especialmente en las situaciones más difíciles.

Descriptores: Compresión Torácica Mecánica; Masaje Cardíaco; Paro cardíaco; Reanimación Cardiopulmonar.

INTRODUCTION

Cardiac arrest is defined as the unexpected and abrupt stop of the heartbeat; it is not associated with aging or chronic and irreversible disease, resulting in a large number of deaths from cardiopulmonary arrest (CPA). In an out-of-hospital context, cardiac arrest is the main cause of death in Europe[1].

Due to the high morbidity and mortality associated with cardiac arrest, it is essential to act accordingly. Thus, in the last 50 years, science has focused on finding the best solutions with regard to cardiopulmonary resuscitation, which is an ongoing task, since survival rates are still, unfortunately, quite low[2].

For cardiopulmonary resuscitation to be as effective as possible, there are several factors that must be considered, with the speed of care as well as the quality of the procedure associated with resuscitation being the most relevant[3]. According to the guidelines of the European Resuscitation Council, of 2021, a quality cardiopulmonary resuscitation must respect the following parameters: adequate frequency, sufficient depth, a total chest return, the minimum possible interruptions during compressions and, finally, professionals duly trained[1].

The survival rate in patients in cardiac arrest is directly linked to the quality of cardiovascular resuscitation as well as the speed with which it is performed. If resuscitation maneuvers are performed immediately, the survival rate is 63.6%. If resuscitation was performed within 5 minutes, the survival rate drops to 37.5%. If resuscitation is carried out more than 10 minutes after cardiac arrest, the survival rate drops dramatically to a worrying 4.5%[3].

Traditionally, cardiac arrest resuscitation is performed through chest compression, which can be manual or using mechanical devices. However, high-quality manual chest compressions are rarely achieved in practice. Therefore, mechanical chest compression devices have the ability to consistently deliver high-quality chest compressions on an ongoing basis[4,5].

Although many studies in human beings show controversial results, its application in pre-hospital environments continues to increase[6]. Thus, the research question arises "what are the advantages of mechanical chest compression devices?". To this end, an integrative literature review was developed, with a broader methodological approach referring to reviews, allowing the inclusion of experimental and non-experimental studies, data from theoretical and empirical literature, for a more complete understanding of the analyzed phenomenon[7].

METHODOLOGY

This study consists of an integrative literature review, guided by the question "What are the advantages of mechanical chest compression devices?". This methodology aims to synthesize results obtained in research on a topic or issue, in a systematic, orderly and comprehensive manner, providing broader information on a subject or problem, thus constituting a body of knowledge[8].

The research was carried out by two investigators and conducted with the combination of the following terms, after consulting the Health Sciences Descriptors (DeCS) and the Medical Subject Headings (MeSH): "cardiopulmonary resuscitation" AND "heart arrest" AND "heart massage" . The electronic search was performed in Pubmed, Cochrane Central and CINAHL databases.

Inclusion criteria for the article were: a) articles that address about the advantages of chest compression devices; b) articles published between 2012 and 2022; c) clinical trials, studies or case series and other literature reviews; d) articles in English and Portuguese; e) articles that used qualitative or quantitative instruments for the proposed evaluations. Articles that: a) did not have chest compression devices as their central theme were excluded; b) repeated and incomplete articles; c) editorials, letters, comments and dissertations.

After searching the databases, the titles and abstracts were analyzed. Those ones that met the criteria or needed further clarification were separated for full review. From the electronic search, 208 studies were then identified after using the given keywords, of which 13 were pre-selected for full reading and only 8 met all the inclusion criteria and, therefore, were selected for this review. Figure 1↗ shows the flowchart, according to the PRISMA methodology, describing each of the phases until reaching the final number of articles included in this review.

RESULTS

Eight articles were selected for this integrative literature review, which met the previously identified inclusion requirements. A descriptive summary of the main aspects of each of the studies is presented in Chart 1↗.

DISCUSSION

As previously mentioned, the survival rate from cardiac arrest largely depends on the quality of the resuscitation process, as well as the speed of patient care. The challenge of providing high-quality manual chest compressions has driven interest in the use of mechanical chest compression that provides chest compressions of consistent rhythm and depth[10].

The use of mechanical devices to perform chest compressions in situations of cardiorespiratory arrest has been shown to be advantageous in studies carried out, due to the increase in rates of return of spontaneous circulation and increased survival until arrival at the hospital when they are applied[10,11]. However, survival to discharge or discharge with a favorable neurological status remains inconclusive[15].

After analyzing the articles included in the present study, it is possible to understand that there is, in the literature, controversy about greater effectiveness of mechanical chest compression devices to the detriment of manual compressions. While authors point to the quality of the compressions, the constant maintenance of the rhythm and the association of the use of mechanical devices with the recovery of spontaneous circulation[10,11], others found that manual compressions proved to be more effective compared to the use of devices mechanics[12].

In the hospital context, mechanical devices have shown advantages for use when it is necessary to prolong circulation to perform interventions such as ECMO (Extra Corporeal Membrane Oxygenation)[11], as well as percutaneous coronary intervention, thrombolytic therapy and performing computerized axial tomography[14].

More recently, and in the context of the Covid-19 pandemic, it was demonstrated that, when performing resuscitation maneuvers using personal protective equipment for aerosol-generating procedures, mechanical chest compression devices should be used for chest

compression of patients with suspected or confirmed communicable diseases, being the main indication and should be used as soon as available, reducing the risk of exposure to communicable diseases to pre-hospital professionals during cardiac resuscitation[13].

Mechanical chest compression devices are shown, in a literature review, to be a complement to resuscitation maneuvers and comply with the standardized recommendations of the European Resuscitation Council, with the same authors stressing that the same recommendations must be followed, with regard to indications for suspending resuscitation maneuvers even if a mechanical device is being used[14]. Although the use of mechanical chest compression devices can replace manual compressions, the authors emphasize the importance of manual compressions always being started early for better neurological results[14].

The same authors refer to the importance of considering the use of mechanical devices in clinical situations where resuscitation maneuvers need to be prolonged, as happens in some intoxications, in case of anaphylaxis, electrocution or hypothermia[14].

Resources in a hospital context are superior to those found in a pre-hospital context, with a greater number of professionals to maintain quality manual compressions, greater physical space, access to more equipment and without the need to mobilize the patient too much, allowing equipment and professionals move to this[15]. In a pre-hospital context, teams are mostly made up of two professionals and there is a need to maintain resuscitation maneuvers in patient evacuation, using immobilization devices, for extraction along winding paths and which still plus transport by land or air to the hospital unit. In this context, mechanical devices for chest compressions proved to be advantageous and more effective than performing manual compressions[10,11,15-17].

During the transport of patients, it is very difficult to perform good quality manual chest compressions, which is very tiring for the rescuer. In this context, the advantage of chest compression devices is related to the possibility of providing chest compressions with constant strength and depth, without compromising the safety of professionals during transport[15] and allowing them to be free to perform other procedures. , such as obtaining a definitive airway and peripheral venous access, for drug administration or other priority interventions[17].

The use of mechanical devices confers other advantages described, such as a higher rate of adequate compressions, a decrease in the total time of suspension of compressions and a reduction in the delay in defibrillation[17]. One more advantage described relates to the possibility of performing defibrillation while maintaining continuous compressions with mechanical devices[14].

Although performing mechanical or manual compressions can lead to injuries, namely fractures, pneumothorax and hematomas, the frequency of traumatic injuries associated with the use of mechanical devices was not higher than manual compressions, confirming the advantage pointed out in the safety of using these devices[16].

CONCLUSIONS

The speed in assisting the patient in cardiac arrest, as well as the quality of the resuscitation are two essential factors for the success of the whole process, representing fundamental variables for the patient's survival. Despite all the advances and efforts of the scientific community, cardiac arrest continues to be the main cause of morbidity and mortality worldwide, which is why a continuous effort is needed to find strategies to counteract this reality.

Mechanical chest compression devices appear, in this sense, as essential tools for the resuscitation of these patients, offering several advantages over manual compressions, especially when resuscitation is being carried out in difficult situations and places, as is the case of transportation in ambulances or air transport, allowing continuous and deep compressions, without causing fatigue to the rescuer, allowing him to be available for other priority interventions in the context of resuscitation maneuvers. Another advantage to be highlighted is the possibility of using mechanical devices in defibrillation, in carrying out complementary diagnostic tests or in invasive interventions such as ECMO.

In addition to the safety they will provide during transport, mechanical devices also allow professionals using personal protective equipment to act, limiting fatigue and protecting them from infectious and transmissible diseases.

Thus, these devices are presented as essential in the context of emergency medicine, according to the literature with the main impact in the prehospital environment, and should be integrated after manual compressions have been started, and it is important that all health professionals have adequate training for its correct operation and handling, optimizing its applicability.

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CC: Study coordination, study design, data collection, storage and analysis, review and discussion of results.
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RA: Study design, data analysis, review and discussion of results.
TA: Study design, data analysis, review and discussion of results.
All authors read and agreed with the published version of the manuscript.

Ethical Disclosures
Conflicts of Interest: The authors have no conflicts of interest to declare.
Financial Support: This work has not received any contribution, grant or scholarship.
Provenance and Peer Review: Not commissioned; externally peer reviewed.

Responsabilidades Éticas
Conflitos de Interesse: Os autores declararam não possuir conflitos de interesse.
Suporte Financeiro: O presente trabalho não foi suportado por nenhum subsídio ou bolsa.
Proveniência e Revisão por Pares: Não comissionado; revisão externa por pares.

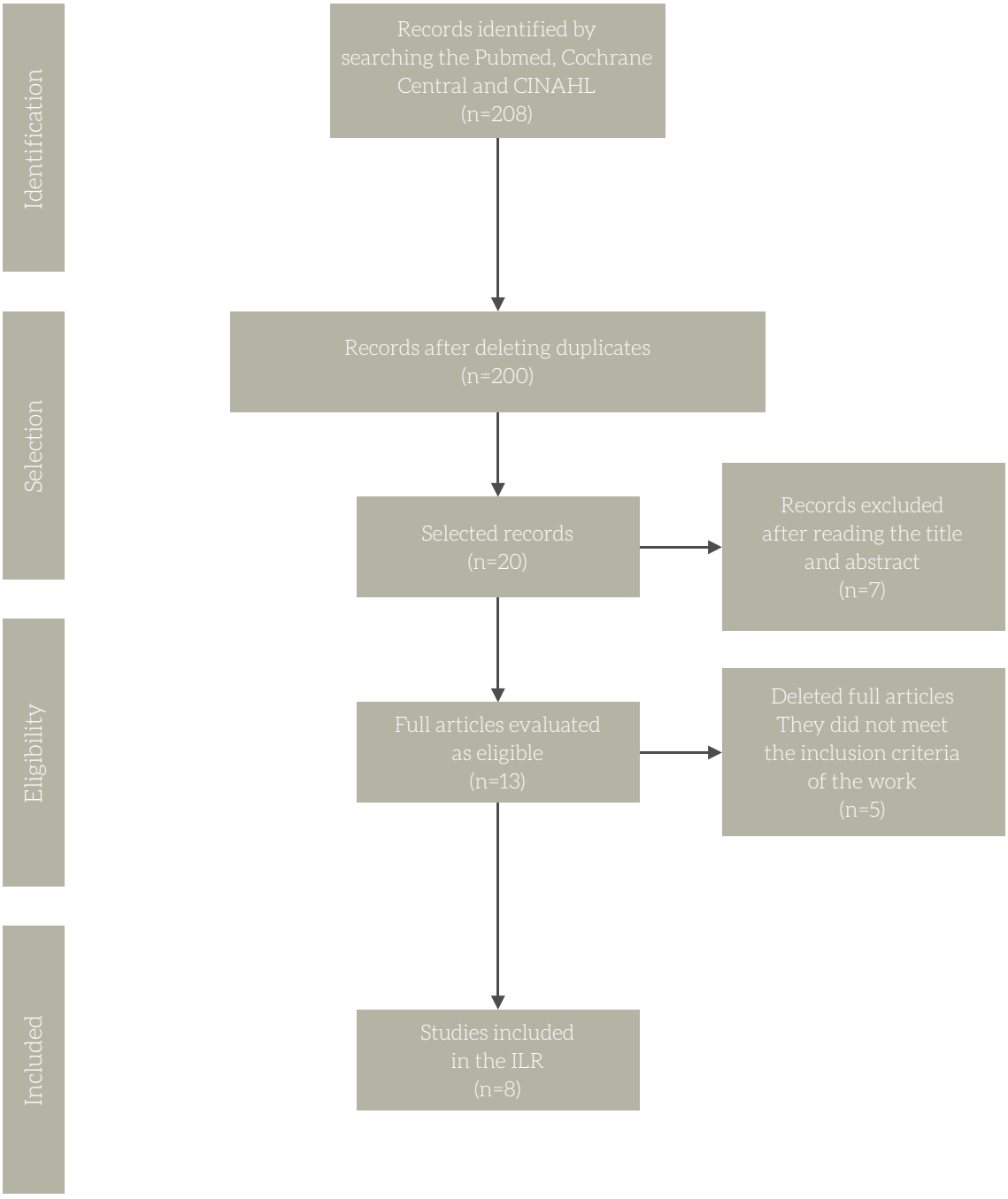

Figure 1 – PRISMA article selection flowchart.[↖]

Chart 1 – Descriptive summary of the included studies.

Title	Authors/Year/ Country/Publication	Objectives	JBI methodology and evidence level	Results	Main conclusions/ implications for practice
The analysis of AutoPulse™ system in flying helicopter.	Omori K, Sato S, Sumi Y, Inoue Y *et al.* 2013. Japan. Resuscitation.	To establish the effectiveness of the AutoPulse™ device in patients in cardiopulmonary arrest (CPA) compared to manual compressions only during helitransport.	Retrospective study with a control group. Evidence level: 2d.	Rates of return of spontaneous circulation and survival to hospital discharge were higher in the AutoPulse™ group compared with the group subjected to manual compressions (ROSC, 30.6% [15 patients] vs. 7.0% [3 patients]; survival until hospital discharge, 6.1% [3 patients] vs. 2.3% [1 patient]).	The present study demonstrates that the use of the AutoPulse™ in helitransport was significantly effective for the return of spontaneous circulation in patients with CRA. The use of automated chest compression devices such as the AutoPulse™ may be recommended for patients in cardiac arrest transported in helicopters.
Impact of automatic chest compression devices in out-of--hospital cardiac arrest.	Kłosiewicz T, Puslecki M, Zalewski R, Sip M, Perek B. 2020. Poland. Journal of Thoracic Disease.	To estimate whether the availability of mechanical chest compression devices for two-man rescue teams had any impact on the efficiency of CPR and the success rate of transporting patients after out-of-hospital cardiac arrest to emergency departments.	Retrospective cohort study. Evidence level: 3c.	Of the 71,282 interventions there were 484 resuscitations performed with complete medical records. The return of spontaneous circulation (ROSC) and transport to the hospital was achieved in 54.9% of the individuals, statistically more frequently among subjects undergoing resuscitation using mechanical devices (63.5%) than those receiving manual compressions (49.8%). Furthermore, the use of the devices was associated with a higher chance of ROSC in younger patients.	The use of mechanical chest compression devices may increase the number of cases with recovery of spontaneous circulation in the pre-hospital setting. We found evidence to suggest that the implementation of these devices in teams of two professionals can improve the quality of resuscitation. In addition, it opens up the possibility of using modern resuscitation techniques such as the ECPR protocol, which can translate into increased survival.

Chart 1 – Descriptive summary of the included studies.↔↖

Title	Authors/Year/ Country/Publication	Objectives	JBI methodology and evidence level	Results	Main conclusions/ implications for practice
Efficacy and safety of mechanical versus manual compression in cardiac arrest – A Bayesian network meta-analysis.	Khan S, Lone A, Talluri S, Khan MZ, Khan MU, Kaluski E. 2018. USA. Resuscitation.	To compare the relative efficacy and safety of mechanical compression devices (AutoPulse™ and LUCAS™) with the manual compression in cardiac arrest patients undergoing cardiopulmonary resuscitation (CPR).	Literature review of randomized controlled trials. Evidence level: 1a.	In an analysis of 12,908 patients with cardiac arrest, manual compression improved 30-day survival, hospital discharge, and neurologic recovery compared with AutoPulse™. There were no differences between LUCAS™ and AutoPulse™ regarding survival to hospital admission, neurologic recovery or return of spontaneous circulation (ROSC). Manual compression reduced the risk of pneumothorax. Manual compressions and the LUCAS™ device reduced the risk of hematoma formation compared to AutoPulse™. Probability analysis ranked manual compression as the most effective treatment for improving 30-day survival or hospital discharge.	Manual compression was shown to be more effective than the AutoPulse™ device and comparable to LUCAS™ in improving 30-day survival or hospital discharge and neurological recovery. Manual compression had a lower risk of pneumothorax formation or hematoma compared to AutoPulse™.

Chart 1 – Descriptive summary of the included studies.↔↖

Title	Authors/Year/ Country/Publication	Objectives	JBI methodology and evidence level	Results	Main conclusions/ implications for practice
An optimal chest compression technique using personal protective equipment during resuscitation in the COVID-19 pandemic: a randomized crossover simulation study.	Malysz M, Smereka J, Jaguszewski M, Dabrowski M, *et al.* 2020. Poland. Kardiologia Polska.	To compare three methods of chest compressions used by professionals in the pre-hospital setting with personal protective equipment.	Multicenter randomized single--blind crossover simulation study. Evidence level: 1c.	Depth of chest compressions, number of compressions per minute, and chest recoil were more often correct when using LUCAS™ compared to the TrueCPR device and manual compressions. A detailed analysis of 2-minute resuscitation with manual compressions showed a decrease in compression depth and total chest recoil after 1 minute of compressions.	During simulated resuscitation using personal protective equipment for aerosol-generating procedures in patients with suspected or confirmed COVID-19, LUCAS™ chest compressions were of higher quality compared to manual compressions as well as the feedback device TrueCPR. If manual compressions are performed by professionals wearing this type of PPE, it is advisable to change the person performing the resuscitation maneuvers every minute.

Chart 1 – Descriptive summary of the included studies.[↔↖]

Title	Authors/Year/ Country/Publication	Objectives	JBI methodology and evidence level	Results	Main conclusions/ implications for practice
Automatic chest compression devices – when do they make sense?	Adams P, Schmitz R, Laister D, Ruther M, Happe D, Sommerfeld P, *et al.* 2014. Germany. American Journal of Emergency Medicine.	To summarize current studies and developments on the use of mechanical chest compression devices and list possible applications.	Literature review. Evidence level: 3b.	The use of mechanical chest compression devices appears to replace manual compressions. In the context of cardiorespiratory arrest, these devices allow simultaneous defibrillation, as well as maintaining the rhythm and depth when there is a need to prolong the maneuvers, such as in the case of intoxication, anaphylaxis, electrocution or hypothermia. In addition to these, other applications have emerged, such as percutaneous coronary intervention, thrombotic therapy and computerized axial tomography. They emphasize the consistency in maintaining chest compressions during patient evacuation by stairs, during ambulance or helicopter transport.	According to current studies, mechanical compression devices are a complement to resuscitation maneuvers and meet what is standardized in the ERC recommendations. Likewise, the suspension of resuscitation maneuvers should follow ERC guidelines, even if the mechanical chest compression device is being used.

Chart 1 – Descriptive summary of the included studies.↔↖

Title	Authors/Year/ Country/Publication	Objectives	JBI methodology and evidence level	Results	Main conclusions/ implications for practice
Comparison between pre-hospital mechanical cardiopulmonary resuscitation (CPR) devices and manual CPR for out-of-hospital cardiac arrest: A systematic review, meta-analysis, and trial sequential analysis.	Chiang CY, Lim KC, Lai P, Tsai TY, Huang Y, Tsai MJ. 2022. Thailand. Journal of Clinical Medicine.	To compare the use of mechanical chest compression devices with manual chest compressions in adults with cardiopulmonary arrest in a pre-hospital setting.	Systematic Literature Review with meta--analysis and sequential analysis. Evidence level: 1b.	After applying the inclusion criteria, 22 articles were selected for review. They found that the use of mechanical devices showed a greater chance of achieving recovery of spontaneous circulation and survival on hospital admission than manual compressions. In a pre-hospital context, the pause in resuscitation maneuvers for patient extraction is shorter when mechanical devices are used. On the other hand, reference is made to the safety of professionals and patients when using these devices in a moving vehicle, such as transport by ambulance to the hospital in resuscitation maneuvers.	This review suggests that the use of mechanical devices in the pre-hospital setting can benefit patients in cardiac arrest. However, survival to discharge or discharge with favorable neurological status remain inconclusive. On the other hand, this review provides the evidence that strengthens the latest advanced life support recommendations for adults, which suggest the use of mechanical devices when high-quality manual compressions are not possible to practice or compromise the safety of professionals, such as during transport by ambulance.

Chart 1 – Descriptive summary of the included studies.↔↖

Title	Authors/Year/ Country/Publication	Objectives	JBI methodology and evidence level	Results	Main conclusions/ implications for practice
Cardiovascular risk factors differently affect the survival of patients undergoing manual or mechanical resuscitation.	Ujvárosy D, Sebestyén V, Pataki T, Ötvös T, Lőrincz I, Paragh G, *et al.* 2018. Hungary. BMC Cardiovascular Disorders.	To analyze the result of manual and mechanical compressions applied in adult patients who suffer sudden cardiac arrest outside the hospital, as well as the effect of risk factors that lead to sudden cardiac arrest on survival.	Retrospective and randomized study, with analysis of the reports of patients assisted in the last 3 years. Evidence level: 4c.	Recovery of spontaneous circulation (ROSC) was achieved in 37% of cases. The use of mechanical compressions allowed the maintenance of higher coronary and cerebral perfusion, which determined the ROSC and the favorable neurological outcome. A positive correlation was established between age and failure resuscitation. An unfavorable correlation was observed between hypertension and the outcome of resuscitation. The presence of left ventricular hypertrophy represents 5.1 times risk of unsuccessful resuscitation. Advanced age and structural heart disease may play a role in causing sudden cardiac arrest.	The frequency of traumatic injuries associated with the use of mechanical devices for chest compressions was not higher when compared with manual compressions. The use of these mechanical devices during cardiopulmonary resuscitation proved to be safe and effective and offered significant help to pre-hospital professionals. Left ventricular hypertrophy and hypertension are the most important factors that negatively affect survival.

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The efficacy of LUCAS in prehospital cardiac arrest scenarios: a crossover mannequin study.	Gyory R, Buchle S, Rodgers D, Lubin J. 2017. USA. Western Journal of Emergency Medicine.	To confirm that the use of LUCAS™ provides higher quality and more consistent chest compressions during patient mobilization and transport.	Controlled crossover observational study. Evidence level: 3d.	Twenty-three professionals participated. Mean time to defibrillation was not different with LUCAS™ compared to manual compressions. With the LUCAS™ device there was a lower average number of compressions per minute, which was more consistent with current American Heart Association guidelines. In addition, LUCAS™ had a higher appropriate percentage of depth, lower total time of suspension of the maneuvers. LUCAS did not perform differently than manual compressions depth of chest recoil and percentage of correct hand position.	In this simulation, the LUCAS™ device had a higher rate of adequate compressions and a total decrease in maneuver suspension time compared to manual compressions, allowing professionals to perform other procedures such as ensuring a definitive airway or establishing venous access for the therapy administration. On the other hand, it was found that with LUCAS™ there is no delay in defibrillation as with manual compressions. The quality of chest compression can be improved when using a mechanical device during the mobilization of the patient in cardiorespiratory arrest in a pre-hospital context.