

Factors related to trauma and chest complications after cardiac massage

RESUMO | Objetivo: identificar quais os principais fatores relacionados às complicações torácicas após massagem cardíaca. Método: Consiste em uma revisão integrativa da literatura. Utilizou-se a estratégia de População, Interesse e Contexto (PICO) para a construção da pergunta norteadora. As buscas foram realizadas entre os meses de julho a setembro de 2021 na Biblioteca Virtual de Saúde (BVS), e bases de dados: Medical Literature Analysis and Retrieval System Online (MEDLINE), Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS) e no serviço da U. S. National Library of Medicine (NLM) PubMed. Após filtragem, foram obtidos 250 artigos que com a leitura criteriosa dos títulos, resumos e aplicação dos critérios de inclusão e exclusão, 10 estudos foram selecionados. Resultados: existem fatores que interferem na eficácia da compressão e podem comprometer a saúde do indivíduo. Conclusão: apesar da massagem cardíaca possuir riscos, é imprescindível a sua realização no atendimento pré-hospitalar da PCR.

Descritores: Traumatismos torácicos; Parada cardíaca; Ressuscitação cardiopulmonar.

ABSTRACT | Objective: to identify the main factors related to thoracic complications after cardiac massage. Method: It consists of an integrative literature review. The Population, Interest and Context (PICO) strategy was used to construct the guiding question. Searches were carried out between the months of July to September 2021 in the Virtual Health Library (VHL), and databases: Medical Literature Analysis and Retrieval System Online (MEDLINE), Latin American and Caribbean Literature on Health Sciences (LILACS) and in the US National Library of Medicine (NLM) PubMed service. After filtering, 250 articles were obtained which, after carefully reading the titles, abstracts and application of the inclusion and exclusion criteria, 10 studies were selected. Results: there are factors that interfere with the effectiveness of compression, which can compromise the individual's health. Conclusion: although cardiac massage has risks, it is essential to perform it in pre-hospital CPA care.

Keywords: Thoracic Injuries; Heart Arrest; Cardiopulmonary resuscitation.

RESUMEN | Objetivo: identificar los principales factores relacionados con las complicaciones torácicas posteriores al masaje cardíaco. Método: consiste en una revisión integradora de la literatura. Se utilizó la estrategia Población, Interés y Contexto (PICO) para construir la pregunta guía. Las búsquedas se realizaron entre los meses de julio a septiembre de 2021 en la Virtual Health Library (BVS) y en las bases de datos: Online Medical Literature Analysis and Retrieval System (MEDLINE), Latin American and Caribbean Literature in Health Sciences (LILACS) y en la Biblioteca Nacional de Medicina de los Estados Unidos. (NLM) Servicio PubMed. Luego del filtrado, se obtuvieron 250 artículos, con lectura atenta de los títulos, resúmenes y aplicación de los criterios de inclusión y exclusión, se seleccionaron 10 estudios. Resultados: existen factores que interfieren con la efectividad de la compresión, comprometiendo la salud del individuo. Conclusión: aunque el masaje cardíaco tiene riesgos, es fundamental realizarlo en la atención prehospitalaria de la CPA.

Palabras claves: Trauma torácico; Parada cardíaca; Reanimación cardiopulmonar.

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INTRODUÇÃO

Cardiac massage is defined as a technique applied for the resuscitation of victims in cardiorespiratory arrest, it has great effectiveness in pre- and intra-hospital care for reducing injuries and preventing the risks of death. However, despite Cardiopulmonary Resuscitation (CPR) being a great differential in cases of CPA (cardiopulmonary arrest), when compressions are not performed properly and efficiently, can cause irreversible or even fatal brain and thoracic lesions, as they directly affect the perfusion of arteries.¹

Spreading knowledge about car-

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diopulmonary resuscitation (CPR) to the population has great value both for lay people and for professionals who teach, since anyone can witness cases of cardiac arrest. Thus, more in-depth knowledge is needed to minimize the risks of complications, morbidity and mortality rates and enable greater efficiency in performing CPR.² Every minute of action with the maneuvers is essential to preserve the time of life, however the less knowledge and experience, the greater the possibilities of failures and injuries.³

CPR requires the performance of compressions with adequate force in the patient's chest. Therefore, the depth and return of the sternum must be observed to ensure greater perfusion to the patient's body (mainly at the brain level) and thus rescue the victim from cardiac arrest. However, it is worth noting that there are situations in which complications, such as rib fractures, breast, thoracic and abdominal injuries, may be unavoidable or due to lack of information resources and, consequently, there is inadequate or prolonged performance of cardiac compressions.⁴

With the emergence of chest compression devices, such as LUCASTM and the "Autopulse", it is believed that there has been a decrease in complications resulting from CPR, since manually the chances of making mistakes are higher because manual compressions do not guarantee the same quality over a long period of time. This is justified by the fact that human beings have limitations, because after a long time performing compressions, fatigue compromises the effectiveness of the maneuver. However, even with such efficiency, these devices are not available in all places or free from causing post-CPR complications, especially when used incorrectly. Thus, both manual and mechanical CPR are subject to errors and post-resuscitation complications.¹

Among the most frequent injuries

caused by cardiac massage are rib and sternum fractures, classified as mild or severe and which may vary according to several factors, the patient's physical condition, abdominal circumference, gender, age, depth, quantity and quality of compressions. Other conditions observed are complications in pneumothorax, pneumomediastinum, and in rarer cases, abdominal injuries to the liver, spleen and stomach.⁵

In this context, the cardiopulmonary resuscitation maneuver is essential in the care of the victim of cardiorespiratory arrest, especially when there is no availability of technological equipment to facilitate the process. Despite this, compressions have risks and consequences that instigate the following guiding question in the present study: What are the factors related to thoracic complications after cardiac massage? In order to identify these complications and thus act in the search for strategies that minimize these potential risks.

Therefore, this study is of fundamental importance in identifying factors related to the occurrence of chest injuries during CPR maneuvers, with the aim of disseminating knowledge that minimizes injuries that may be irreversible to victims. Therefore, this study aimed to identify the main factors related to the occurrence of thoracic complications related to cardiac massage.

METHOD

The method of the present study is an integrative review with the purpose of gathering and synthesizing research results on the emergency area with the purpose of deepening the knowledge of the investigated topic.

The study comprised the following steps: I) identification of the theme and selection of the problem question for the elaboration of the integrative review; II) establishment of criteria for inclusion and exclusion of studies/sampling or literature search; III) definition

of the information to be extracted from the selected studies/categorization of the studies; IV) evaluation of studies included in the integrative review; V) interpretation of results; VI) presentation of the review/synthesis of knowledge.⁶

The guiding question of this review was: What are the factors related to thoracic complications after cardiac massage? Thus, for better guidance regarding the formulation of the research question and answers to the guiding question, the Population, Interest and Context (PICO) strategy described in Figure 1 was used.

Based on the research question, the DeCs and Medical Subject Headings (MeSH) descriptors were defined, both aimed at standardizing the language of the articles indexed in the databases. DesCs were used: traumatismo torácico; parada cardíaca; ressuscitação cardiopulmonar. As for the MeSHs, the following were used: thoracic injuries; heart arrest; cardiopulmonary resuscitation with the Boolean operator AND.

The research was carried out in libraries (VHL) and (PUBMED), virtual libraries are places that bring together articles, books, visual and audio materials and publications from different areas that complement each other, thus covering several databases, which are more specific in certain areas and group together articles with similar and related subjects. This search was carried out with the adoption of inclusion and exclusion criteria for the selection of materials, which refer to the articles used to prepare this work.

From this, the structured data collection started in July 2021, with advanced search, as it allows interconnecting descriptors in order to refine the search in the databases: System Online (MEDLINE), and Latin American and Caribbean Literature on Health Sciences (LILACS), these databases were accessed through the Virtual Health Library (VHL).

The data search was done in pairs

and the decision to include or exclude the studies was their responsibility, but with a secondary help in order to review the selection choices, a third author was needed.

The selection of articles was premeditated from the careful reading of the titles and abstracts of the findings in the literature, in order to select the articles that met the inclusion and exclusion criteria. The inclusion criteria defined were all studies that met the objective of the research and without time limit, and the exclusion criteria were defined in readings of no interest due to escape from the topic and articles not available in full or repeated. Review studies were also not considered, it was decided not to establish a specific language in order to gather as many studies as possible on the defined topic.

The searches were carried out respectively at three times in the months of July, August and September 2021. The first search for studies took place in the Virtual Health Library (VHL), using the search strategies: (Traumatismos Torácicos) AND (Parada cardíaca) resulting in 244 studies, using the MEDLINE and LILACS databases, 63 articles were obtained, after reading the titles and abstracts, 6 articles were selected and after applying the inclusion and exclusion criteria and reading the articles, 2 studies were selected as the final result and are included in the present study.

The second search carried out at PUBMED using the search strategies: (Thoracic injuries) AND (Heart arrest) resulted in 719 articles, with the application of the free full text filter, 112 studies were obtained, after reading the titles and abstracts, 8 articles were selected and after applying the inclusion and exclusion criteria and reading the articles in full, 1 article was obtained.

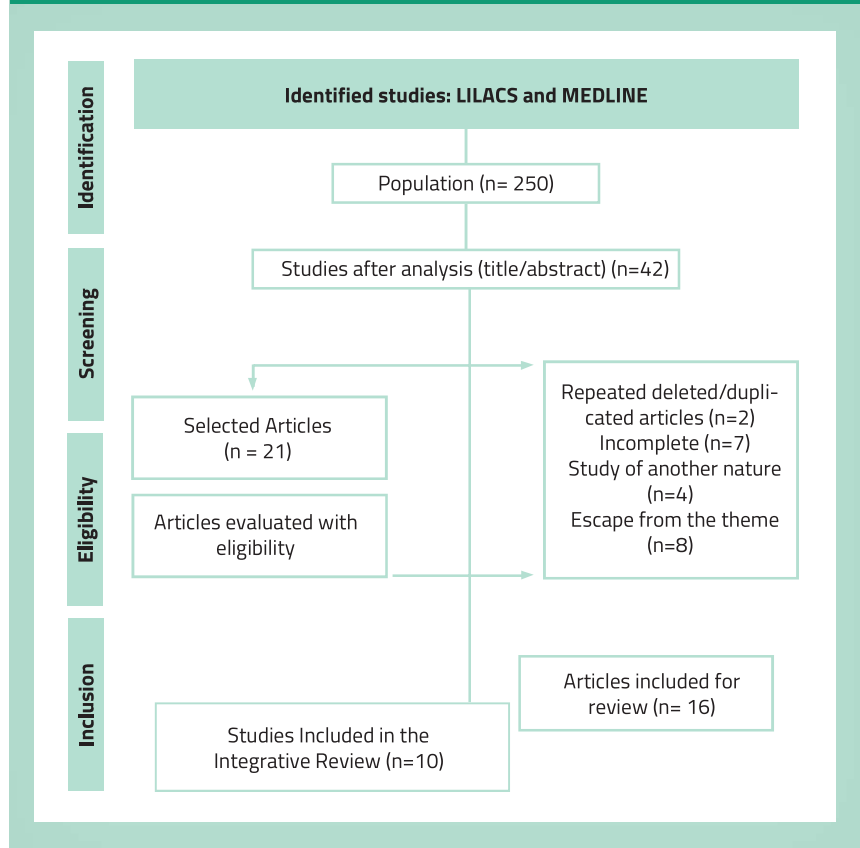
The third search also carried out in PUBMED was used MeSH Cardiopulmonary resuscitation, Thoracic Injuries, using Boolean operator AND resulted in 459 articles, with the application

FIGURE 1: Descriptors of subjects in DECS and MESH, through the PICO strategy, for the construction of the guiding question. Crato- CE, Brazil, 2021.

Strategy Items	Components	Descriptors of the subject (DeCS)	Descriptors of the subject (MeSH)
Population	Patients undergoing cardiopulmonary resuscitation		
Interest	Factors related to thoracic complications in cardiac massage.	- Traumatismo torácico. - Parada cardíaca - Ressuscitação cardiopulmonar	Thoracic Injuries Heart Arrest Cardiopulmonary resuscitation
Contexto	Emergency		

SOURCE: Prepared by the authors, 2021.

FIGURE 2 – Flowchart referring to the article search and selection process, Crato, CE, Brazil, 2021.



SOURCE: Prepared by the authors, 2021.

of the free text filter, 75 articles were obtained and after reading all the titles and abstract, 10 articles were selected for complete reading, including 7 that met the inclusion criteria.

In short, 250 studies were analyzed, excluding a total of 208 after reading titles and abstracts, and selecting a total of 42 studies for full reading, of which 21 were selected for analysis in order to make it possible to choose the 10 articles that make up this review.

The Preferred Reporting Items for Systematic Review and Meta Analyses (PRISMA) instrument demonstrates the process of searching and selecting studies, as shown in Figure 2.

Data were evaluated, considering the Oxford Center Evidence Based Medicine classification system to delimit the levels of evidence of the studies included in the review, as shown in Figure 3.

For a better final demonstration of the collected studies, there was the organization by thematic categories developed in Figure 4, which will be presented in the results to better elucidate the findings, it contains information, such as Author/place/type of study/level of evidence (LE), article title, objective, results and conclusion.

RESULTS

The sample of this review consisted of ten studies that address the factors and complications resulting from chest compressions during CPR.

The conformation of this figure allows a careful evaluation of the findings and the comparison between the different factors that can contribute to the possible injuries caused during the execution of the CPR protocol. However, the potential complications do not outweigh the need for cardiac massage to reverse CRP.

DISCUSSION

FIGURE 3 - Levels of evidence by study type. 7 Crato, CE, Brazil, 2021.

LE*	TYPES OF STUDIES
1A	Systematic reviews of randomized controlled clinical trials
1B	Randomized controlled clinical trial with a narrow confidence interval.
1C	All-or-Nothing Therapeutic Results
2A	Systematic Review of Cohort Studies
2B	Cohort Study (including lower quality Randomized Clinical Trial)
2C	Research results (observation of therapeutic results or clinical evolution)
3A	Systematic Review of Case-Control Studies
3B	Case-Control Study
4	Case Reporting (including cohort or lower quality case-control)
5	Expert opinion devoid of critical evaluation or based on basic materials (physiological study or animal study)

SOURCE: "Oxford Centre for Evidence-based Medicine", 2021.

LE* - Level of Evidence

It is observed that the factors that are linked to complications in the chest wall after cardiopulmonary resuscitation are often unavoidable, since even pathological, anatomical problems, gender and age of some patients favor the emergence of some injuries or traumas.⁸ Thus, some uncommon complications may arise, such as pulmonary hernia associated with hemothorax being characterized as a protrusion in the lung.⁹

On the other hand, the literature points out that factors such as the use of mechanical compression devices and the change in guidelines considered outdated, corroborate some complications. For example, there are some studies that mention the differences in the 2005 and 2010 editions of the American Heart Association Guidelines, and compare the changes regarding the depth of massage, where a depth of 38 to 50 mm was recommended in the 2005 guidelines, while in 2010 it advocated a depth of 50 mm, which is equivalent to 5 cm. However, massage with this value has more risk of chest

complications.¹⁰

Associated with this line of thinking, studies were carried out with the objective of identifying the relationship between these compressions suggested by the guidelines and the complications resulting from them, stating that rapid and deep compressions increased the proportion of complications such as retrosternal and mediastinal hematomas and rib fractures.¹¹ It was also noted in some studies that there were no significant differences between the 2010 and 2015 guidelines.¹²

One of the precursors to some complications is the previously mentioned chest compression devices, namely the Corpuls cpr, LUCAS™ and Autopulse, which are widely used in pre-hospital and clinical emergency care and which facilitate cardiac massage by allowing high quality cardiopulmonary resuscitation (CPR) providing good blood supply to the organs.¹³ However, these mechanical devices are used when available and considered one of the factors that can also lead to the appearance of fractures.

FIGURE 4 – Presentation of the synthesis of articles included in the integrative review. Crato, CE, Brazil, 2021.

Author/ Study Type	Levels of Evidence (LE)	Journal / language	Title	Objectives	Results	Conclusion
(LIAO et al., 2010)/ Controlled clinical trial / Observational study / Risk factors	LE 4	Scand J Trauma Resusc Emerg Med/ English	Standardized assessment of post-resuscitation damage from two mechanical chest compression devices: a prospective randomized large-animal study.	To compare the effectiveness of CPR and chest injuries of two mechanical chest compression devices in pigs	Both animals in the mCCD1 and mCCD2 group reached HCR but only the mCCD1 animals survived until the end of the monitoring period compared to the mCCD2 group that showed significantly more severe chest injuries.	LUCAS 2 device shows superior resuscitation results and less chest injuries compared to Corpuls cpr when used for experimental CPR in young pigs
(KRALJ et al., 2015) / Study of incidences	LE 4	Resuscitation/ English	The frequency and number of resuscitation-related rib and sternum fractures are higher than generally considered.	Establish the incidence, number and location of CPR-related skeletal chest injuries (SCI) and investigate the influence of age, gender, changes in resuscitation guidelines and resuscitation technique.	External cardiac massage caused injuries in both groups with similar values and observed that changes in guidelines were considered risk factors, as well as it was noted that the use of the LUCAS device had no adverse effects.	At least 1/3 of resuscitated patients are thought to have rib fractures and at least 1/5 to have sternum fractures.
(KAWAKAMI et al., 2016) / Case Reports	LE 4	Internal Medicine/ English	Internal mammary artery injury related to chest compressions in a patient with post-cardiac arrest syndrome	Demonstrate chest compression-related mammary artery injuries	In the specific patient who had postoperative adhesions between intrathoracic blood vessels, sustained chest compressions could lead to IMA injuries.	While high-quality CPR is essential for survival from cardiac arrest, chest compressions can lead to chest injury and life.
(AZELI et al., 2019)/ Incidence study / Screening study.	LE 2B	Emergências : revista de la Sociedad Española de Medicina de Emergências/ Spanish and English	Serious injuries secondary to cardiopulmonary resuscitation: incidence and associated factors	To determine the incidence of severe rib cage damage (SRD) and severe visceral damage (SVD) secondary to cardiopulmonary resuscitation (CPR) and explore associated factors.	SRD was found in 63.3% and SVD in 14.7%. The SRD group was significantly older and had an abdominal circumference greater than 100 cm, with a circumference greater than 101 being considered a risk factor.	Women and any patient with a chest circumference greater than 101 cm are at increased risk of serious CPR-related injuries.
(JANG et al., 2020) / Observation Study / LE 3B	LE 3B	Medicine (Baltimore) / English	Computed tomographic findings of chest injuries after cardiopulmonary resuscitation.	To investigate lung parenchyma and thoracic skeleton injuries after CPR using computed tomography (CT) and analyze the correlation between CPR duration and related complications	The distribution of pulmonary contusions was predominantly in the bilateral dependent portions of the lungs (41 patients). All rib fractures occurred in the anterior arch (43 patients), and sternal fractures occurred predominantly in the middle of the sternal body (31 patients). However, there was no statistically significant correlation between CPR duration and CSF or other CPR-related chest injuries.	The duration of CPR was associated with the number of rib fractures and the occurrence of sternum fractures, but did not affect the extent of CPR-related Lung Contusions or other CPR-related chest injuries.
(BOZ et al., 2008)/ Original Article Clinical Study	LE 2B	Turkish Journal of Trauma & Emergency Surgery / Turkish	Frequency of skeletal chest injuries associated with cardiopulmonary resuscitation: forensic autopsy	To determine the incidence of rib and sternum fractures after conventional closed-chest compression in the treatment of cardiac arrest.	There were no significant differences between groups according to age, sex, and traumatic-non-traumatic cause in terms of CPR-associated skeletal chest injuries in adult patients.	It shows a low incidence of rib and sternum fracture after closed chest compression in the treatment of cardiac arrest in forensic autopsy cases.

(BEOM JH., 2017)/ Control case	LE 3B	Scand J Trauma Resusc Emerg Med /English	Investigation of complications secondary to chest compressions before and after changes in the 2010 cardiopulmonary resuscitation guidelines using multidetector computed tomography: a retrospective study	To identify the relationship between the deeper and faster chest compressions suggested by the 2010 cardiopulmonary resuscitation guidelines and complications resulting from chest compressions, using multi-detector computed tomography	The most frequent complication to occur in both patient groups in the pre-2010 and post-2010 groups, respectively was rib fracture there were no statistical differences in sternum fracture, retrosternal and mediastinal hematoma form identified in a post-2010 group	The 2010 guidelines recommending deeper and faster chest compressions led to an increase in the proportion of rib fractures and retrosternal and mediastinal hematoma.
(LIAO et al., 2010)/ Comparative study	LE 2B	BMC Cardiovasc Disord / English	Manual versus mechanical cardiopulmonary resuscitation. An experimental study in pigs	The aim of the present study was to compare manual CPR with LUCAS-CPR.	The mean coronary perfusion pressure was significantly higher in the mechanical group, in relation to rib fractures, the highest index was in manual compressions. In the manual group, a severe liver injury and a pneumothorax. The number of pigs in the mechanical group that achieved ROSC was higher.	LUCAS-CPR gave significantly greater coronary perfusion pressure and significantly fewer rib fractures than manual CPR in this porcine model.
(EMBERGER et al., 2011)/ Case report	LE 4	Respir Care / English	Pulmonary hernia associated with hemothorax after cardiopulmonary resuscitation	To report a case of thoracic pulmonary hernia that occurred 2 days after traumatic cardiopulmonary resuscitation, after the formation of a large hemothorax	The patient had a pulmonary hernia at the site of traumatic cardiopulmonary resuscitation.	After traumatic cardiopulmonary resuscitation, pulmonary hernia may occur.
(YUSUFOĞLU et al., 2018)/ Comparative study	LE 2B	Turk J Med Sci / Turkish	CPR-related chest injuries: comparison of CPR guidelines between 2010 and 2015	Avaliar as complicações traumáticas do tórax em pacientes pós-RCP e investigar se houve ou não redução dessas complicações desde a adoção das recomendações atuais de compressão torácica.	Of patients in the 2010 AHA guideline, 39.21% had pulmonary contusion, while 54.83% of patients in the 2015 ERC guideline had pulmonary contusion. 11.76% of patients in the 2010 AHA guideline and 3.22% of patients in the 2015 ERC guideline were found to have pneumothorax, while 9.8% of 2010 AHA guideline patients and 12.9% of 2015 ERC guideline patients had hemothorax.	The incidence of CRP-related injuries did not decrease with application of new recommendations from the 2015 ERC CPR guidelines

SOURCE: Prepared by the authors, 2021

The LUCAS™ device is a CPR device that provides automatic 5 cm deep compressions at a rate of 100 compressions per minute, its decompressions allow for a normal return of the chest. In this way, LUCAS™ is adjusted for chest compressions as required by current guidelines.¹⁴

According to some studies, there was no adverse effect with the use of the LUCAS™ device.¹⁵ However, according to research, mechanical chest compression adjunct to manual chest compression was strongly associated with potentially fatal visceral injuries.¹⁶ Thus, the use of some mechanical

device increases the probability of visceral or thoracic complications after cardiopulmonary resuscitation.

Despite this, with the use of these mechanisms of mechanical compressions, it was noted that the return of spontaneous circulation was greater and faster in the population that used

the devices, thus demonstrating the risk benefit. Therefore, it is up to the team responsible for the individual in cardiac arrest to choose the best device to be used in the most diverse situations, according to current protocols and taking into account the victim who is already traumatized or the availability of such equipment in the care unit.

It was also observed that, in addition to the changes requested by the guidelines and the electronic mechanisms used, the incidence of traumatic complications after cardiopulmonary resuscitation is influenced by gender and chest circumference greater than 101 cm, which favors a higher risk of injuries secondary to resuscitation maneuvers.¹⁷

However, it should be noted that previous studies show a low incidence of rib and sternum fractures, stating that there are not such significant differences in relation to sex, age, traumatic and non-traumatic causes.¹⁸ In contrast to this information, a study brings new information related to age, and ensures that there is relationship with chest trauma caused by cardiac massage, as advanced age is a single independent

factor that is related to thoracic skeletal injuries.¹⁹

Thus, it is determined that the factors related to complications and trauma to the chest wall come from certain methods used for the maneuvers, the patient's condition and devices that help in the management of compressions, each body, institution and professional is responsible for the proper use of these devices.

CONCLUSION

From the present study, it was possible to observe and conclude that manual or mechanical cardiopulmonary resuscitation methods, through the aid of devices such as LUCASTM, Corpuls cpr and Autopulse, are beneficial and necessary in emergencies of cardiopulmonary arrest. However, they present the possibility of causing injuries and traumas of varying degrees that are mainly related to the time, depth, force of compressions, factors related to the victim's age, gender and chest circumference. Among the main complications, we highlight trauma to the ribs and sternum, lesions in the breasts

and thoracic region, pulmonary contusions and retrosternal and mediastinal hematomas.

In this sense, there is a need to follow the guidelines recommended by the AHA, for performing compressions correctly and for the proper use of electronic devices, in order to minimize post-CPR complications in patients.

It should be noted that despite the risk of some damage due to the performance of cardiac compressions, these are still the most efficient way to reverse CRP, and should be performed in pre- and intra-hospital care whenever necessary, as the patient's life is valued first, even in the face of these risk factors.

In this context, the role of nursing in the care of patients in cardiorespiratory arrest and the need for their qualification to identify the risks and seek improvements for the correct and effective performance of compressions (manual or through devices) is also highlighted, because one of the principles of nursing is to provide health care with efficiency and quality, equipped with technical-scientific knowledge.

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