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Original article

Cardiopulmonary Resuscitation CPR Quality Outcome of Patients with Cardiac Arrest by Using Robotics/ Artificial Intelligence in Hospitals

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Abstract

Background: The life-saving procedure is required rapid and effective methods to keep patients survive. Some literature reviews demonstrate those robotic medical systems like the applications as chest compression manipulators, which applied to enhance the quality during cardiopulmonary resuscitation in hospitals and because the number of studies that talked about the importance of using robotics was few This paper will be discussed Using of robotics and artificial intelligence (AI) during cardiopulmonary resuscitation in hospitals focusing on the level of efficiency of the outcome based on systematic reviews studies. ***Methods:*** This is a systematic review is based on collecting all previous articles which were done on the using Cardiopulmonary resuscitation CPR quality outcome of Patients with cardiac arrest by using Robotics/ Artificial Intelligence in hospitals. ***Results:*** The review process involved determining the suitability of 46 publications. There were 22 papers that made it through the full text screening and into the final review. The purpose of this research was to assess and improve outcomes for patients with cardiac arrest using robotics/artificial intelligence during CPR in hospitals. ***Conclusion:*** Robots and artificial intelligence have created a device that can reduce the risk of saving patients. It is safe, affordable, and accessible in real time, and more precise instrumentation and controls can adapt the massage to the rigidity of the patient's rib cage or clinical presentation.

Keywords: ***CPR, Artificial Intelligence, Robotics.***

Introduction

Cardiopulmonary resuscitation is a potentially life-saving technique. that requires rapid and effective methods [1]. The compression rate of about 100 beats to 120 beats times per minute for adults with a depth of 4 to 5 centimetres using the hands. The compression-to-ventilation ratio is usually done by two rescuers, from 15 to 2 breaths per minute in the first 15 minutes [2]. It is good with the rapid development of electronics, computer technology and physical element base. It focuses on introducing new materials with unique features and increasing computer power that enabling the evolution of a new class of robotic medical systems with diagnostic and treatment skills [3]. According to official statistics, it shows that in Europe and the United States, CPR is require1-5 times per thousand hospitalized patients (CPR) [4]. On the other hand, in cardiac arrest, the amount of cardiac output (about 20% to 30% of average output) remains approximately the same. While performing CPR, the stress of the performers may decrease the quality of compressions [5].

Therefore, it is crucial to understand that it is still safe to do CPR for patients who have had a cardiac arrest but, it may increase the chances of spreading various infections to these patients. Contrarily, once they design compressor of the mechanical chest devices to automate and possibly improve the procedure; Thus, it is perfect for hospital usage [6]. It is worth mentioning that fatigue is one of the main reasons for the poor quality of CPR by the rescuer, so manual CPR is an extensive process and difficult to maintain even If the saviour is physically fit [7]. Also, when ten doctors circulated to do two hours of chest compressions, it showed that these doctors could better use their valuable time with the chest compression assistive medical robot [8].

Perhaps one of the reasons is, as the researcher' knowledge, there is nothing in the literature dealing with parallel robotic systems that could assist in CPR published so far in this field [9]. With the growth of knowledge as an improved version of the DELTA parallel robot for CPR, RRPaR modify. Moreover, an enhanced version of the DELTA Cardiopulmonary resuscitation parallel robotic system, the 3-RRPaR, is adjusted. 3-DOFa parallel manipulator has, nevertheless, just a few studies, is used and examined throughout the literature to use parallel manipulators to aid in CPR [10].

From the perspective of development and progress and the importance of preserving human health, we conducted a systematic review to assess and improve the quality of outcomes for patients with cardiac arrest using robotics/artificial intelligence during CPR in hospitals. This is done through: analysing and reviewing the history and development of the current application of robotics and artificial intelligence in the field of CPR.

Materials and Methods

Study design

This is a systematic review is based on collecting all previous articles which were done on Cardiopulmonary Resuscitation CPR quality outcome of patients with cardiac arrest by using Robotics/ Artificial Intelligence in hospitals from the date 2011 to 2021 by using meta-analysis.

As a systematic literature review study was done by using the PRISAM checklist to be more comprehensive studies, and most articles was conducted between 2011 and 2021, with different studies design (experimental, non-experimental, RCT), published on journals with high IF.

All studies which conducted before 2011, all type of studies used case report, case series, unpublished articles, children participant, out-hospital cases was excluded.

Search strategy

An intensive literature search will be conducted in order to provide a full narrative to evaluate the outcome of excellent CPR employing robots and artificial intelligence. We choose papers that were published in English between 2011 and 2021. We used keywords such as robots and cardiopulmonary resuscitation, artificial intelligent and cardiac arrest, and robotics and cardiac arrest to search the databases (Web of Science, Springer, Google Scholar, and Science Direct). The studies were chosen based on the titles, abstracts, and techniques found in electronic searches, as well as full texts.

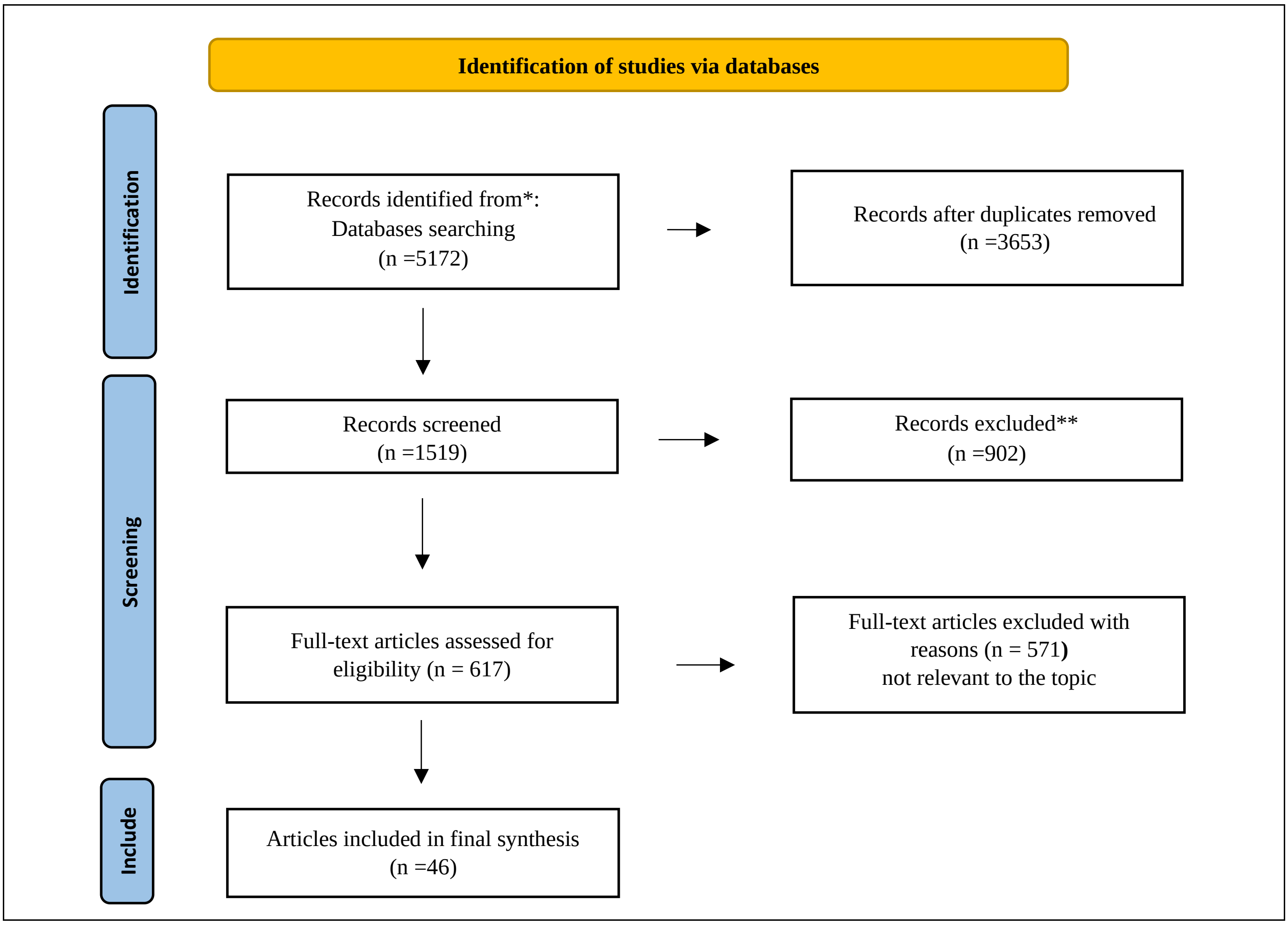
Study selection and data extraction

Managing citations using Mendeley. We were successful in removing the duplicating article. Two reviewers verified and assessed the complete content of the prospective publications by studying the abstract and title of each connected paper. Two reviewers extracted the result and study characteristics individually and anonymously using the updated data extraction form.

Table 1. Demographic Characteristics of Studies Results

Title	Country	Year of publication
1. Asgari M, Ardestani MA. Dynamics and improved computed torque control of a novel medical parallel manipulator: Applied to chest compressions to assist in cardiopulmonary resuscitation. J Mech Med Biol 2015; 15: 1–23.	Iran	2014
2. Yedukondalu G, Kumar JS, Srinath A, et al. Dynamic Analysis and Optimization of Delta Parallel Robot for Chest Compression Task. 2013; 151–154.	India	2013
3. Gryaznov NA, Senchik KY, Kharlamov V V., et al. Development of new external chest compression robotic system for cardiopulmonary resuscitation using the principles of theranostics. *Am J Appl Sci* 2016; 13: 230–235.	Russia	2016
4. Gryaznov NA, Senchik KY, Kharlamov V V., et al. Development of algorithms for the external cardiac compressor of original design. *Indian J Sci Technol* 2015; 8: 1–6.	Russia	2015
5. Rao GB, Kumar MW, Sahu M, et al. Usage of parallel manipulator for external chest compressions during cardiopulmonary resuscitation - An experimental study on feedback manikin. Int J Mech Eng Technol 2018; 9: 990–998.	Denmark	2018
6. Dharniju Reddy T, Yedukondalu G. Chest compression for cardiopulmonary resuscitation with a 3-PRR parallel manipulator. *Int J Mech Eng Technol* 2016; 7: 660–667.	India	2016
7. Alam MM, Amin MA, Hussain M, et al. Design of piston-driven automated cardiopulmonary resuscitation device with patient monitoring system. 1st Int Conf Robot Electr Signal Process Tech ICREST 2019; 211–216.	Banglades h	2019
8. Suat C. Computed Torque Control of a Medical Parallel Manipulator. 2018; 33.	USA	2018
9. Li Y, Xu Q. Design and development of a medical parallel robot for cardiopulmonary resuscitation. IEEE/ASME Trans Mechatronics 2007; 12: 265–273.	China	2007
10. Yedukondalu G, Patnaik S, Venkatesh PL, et al. Chest compression with 2-DOF parallel manipulator for cardiopulmonary resuscitation. Int J Eng Technol 2018; 7: 211–215.	India	2018
11. Jung J, Kim J, Kim S, et al. Application of Robot Manipulator for Cardiopulmonary Resuscitation. Springer Proc Adv Robot 2017; 1: 266–274.	Korea	2017
12. Rajagopalan B, Shen WK, Patton K, et al. Surviving sudden cardiac arrest—successes, challenges, and opportunities. J Interv Card Electrophysiol. Epub ahead of print 2021. DOI: 10.1007/s10840-021-00969-1.	USA	2021
13. García AM, Eichhorn S, Polski M, et al. Simulation of an Electro-Mechanical Resuscitation Device for Cardiopulmonary Resuscitation German Heart Center Munich, Clinic for Cardiovascular Surgery , Technische Universität München ,. 0: 3–6.	Germany	2014
14. Shinde MBN, Narkhede S, Wagh H, et al. GSM Base Automated CPR Device Using Scotch-Yoke Mechanism. Int J Adv Res Sci Commun Technol 2021; 5: 347–353.	India	2021
15. Jiang L, Min J, Yang F, et al. The optimal chest compression point on sternum based on chest-computed tomography: A retrospective study. Hong Kong J Emerg Med 2020; 27: 197–201.	China	2020
16. Remino C, Baronio M, Pellegrini N, et al. Automatic and manual devices for cardiopulmonary resuscitation: A review. Adv Mech Eng 2018; 10: 1–14.	Italy	2018
17. Jalali A, Berg RA, Nadkarni V, et al. Model based optimization of the cardiopulmonary resuscitation (CPR) procedure. Proc Annu Int Conf IEEE Eng Med Biol Soc EMBS 2012; 715–718.	USA	2012
18. Gupta A, Singh A, Bharadwaj D, et al. Humans and Robots: A Mutually Inclusive Relationship in a Contagious World. Int J Autom Comput 2021; 18: 185–203.	India	2021
19. Rodr E, Kypson AP, Moten SC, et al. Robotic mitral surgery at East Carolina University: Int J 2006; 211–215.	India	2006
20. Sung CW, Wang HC, Shieh JS, et al. A novel mechanical chest compressor with rapid deployment in all population cardiopulmonary resuscitation. Sci Rep 2020; 10: 1–10.	Taiwan	2020
21. Recognition for Robot First Aid.	Sweden	2016
22. Narula A, Narula NK, Khanna S, et al. Future prospects of artificial intelligence in robotics software, a healthcare perspective. Int J Appl Eng Res 2014; 9: 10271–10280	India	2014

Method for data collection and instrument:
By utilizing diverse sources for data collection such as Google scholar and Springer, Sci -Hub, Science direct.



Results And Discussion

In all, 5172 items were found from the first search. Total duplicate content was reduced by 5165 articles. The initial pool of publications was 5165, with the remainder having been eliminated based on filters applied to their titles and abstracts to weed out anything unrelated to the overarching aims of this study. The review process involved determining the suitability of 46 publications. There were 22 papers that made it through the full text screening and into the final review. The purpose of this research was to assess and improve the quality of outcomes for patients with cardiac arrest using robotics/artificial intelligence during CPR in hospitals. This is done through: analyzing and reviewing the history and development of the current application of robotics and artificial intelligence in the field of CPR.

Improve the quality of outcomes
As noted in the results of the robot CPR assessment, the expected advantages include not only a high resuscitation rate in clinical practice but also a reduced cost in terms of manpower [11]. On anther hand, according to international accreditation standards related to cardiac arrest programs and continuous quality improvement programs might help eliminate the significant gaps between SCA detection, treatment, and outcomes across the different regions [12]. So the next stages will be to modify patient parameters and have the system recognize patient features and probable changes in compression resistance caused by tissue warming up and avoid rib rupture caused by the application of excessive force [13].

Assist in CPR operation
The methodology permits robot weight optimization. Both initial and optimized Model weights are determined, with a 50% decrease. The work gives a solid foundation for developing a medical robot to aid in CPR, which may minimize the robot's weight [2]. These studies give a strong foundation for developing a medical robot to help with CPR, which may lessen the danger and effort of clinicians saving patients to protect the patient's ribs and heart [9].

Effective of automated CPR device
The concept was designed to avoid complications with manual CPR and be simple to use with minimum training. Mechanical alterations may be performed quickly since the base plate is numbered with that in mind [14]. No doubt that, high-quality CPR improves cardiac arrest patients' prognosis. But fewer research have focused on the ideal chest compression site. The ideal compression point should generate perfusion pressure effectively, be readily identifiable, and have less difficulties [15]. It is important to focus on designing a CPR apparatus that also monitors vital indicators with cheap motor crankshaft as the CPR device's chest compression and patient monitoring system, so the operator can examine the patient's vitals while performing CPR [7]. As known a better effectiveness indicates a larger percentage of ROSC, survival with a good neurological prognosis, and no rib cage and abdominal injuries. Massage must be precise, constant, and safe [16]. Not only 2-DOF 2-RRR parallels robot was developed for CPR chest compressions. Static analysis shows the paralleled operator can withstand mobility-related loads. But also the 2-RRR manipulator can achieve 50 millimeter depth and 100 compressions per minute, according to biomechanical analysis and simulation results. These simulations results match AHA CPR guidelines [10]. This study presented a new chest compression spatial parallel manipulator. So we propose to make a device that could reduce the

risk of rescuing patients compared to the traditional CPR [1]. The effectiveness of integrating a theranostic automated external cardiac compressor into modern medicine can be achieved by incorporating it as part of a larger system, but theranostic features of this larger system should be considered [3].

Optimization CPR procedure

The expected benefits of robot CPR include a high resuscitation rate in clinical practice and reduced manpower costs. If the optimal compression position can be automated, the robot CPR system will be even more effective. As it acts and measures data precisely, the robot CPR can be used to investigate CPR in future experiments [11]. Two approaches are examined. First, optimize oxygen delivery by finding the optimal values of the free parameters and "performing" CPR with these values. Second, we use a sequential optimization scheme to maximize oxygen delivery in each CPR sequence. In sequential optimization, at each sequence, the rescuer performs CPR with an optimal compression-to-ventilation ratio, maximizes his/her performance based on that ratio, and then performs CPR again with a new optimized ratio. Results show that sequential optimization improves CPR performance [17]. The designed manipulator makes it easy to perform cardiopulmonary resuscitation at the correct rate, time, and depth. This research seeks a safe and effective way to rescue cardiac arrest patients [6].

Robots in hospitals

Robotics and automation protect humans and deliver food and sanitize hospitals and medicines around the world. Social distance is one solution. Population density makes this difficult in many developing countries. COVID-19 has shown a need-driven change in global technology adoption behavior. This pandemic has highlighted our health care system's weaknesses. Robotics, AI, UAVs, telehealth, telemedicine, etc. have ample opportunities to overcome the gap and prove their effectiveness. Telemedicine and telehealth have helped the health system avoid collapse. It's safe, affordable, accessible, and real-time [18].

Safety outcomes

This paper proposes a robot CPR system that meets international guidelines and improves CPR. Here's the main takeaway from each experiment. Robot CPR outperforms traditional CPR in the first experiment. In the second experiment, CPR with the robot manipulator increased resuscitation rates without causing special injuries [11]. Most rescuers perform cardiopulmonary resuscitation (cpr based on clinical experience, not how to deliver safe and effective compressions. In a hospital, resuscitating a patient takes 2 h of compressions. No optimal method exists for achieving and maintaining adequate blood flow while minimizing rib fracture, liver laceration, and other injuries [19]. The suggested manipulator is aimed to boost the chances of overcoming cardiopulmonary arrest while reducing rescuer effort [6]. Advances in technology and understanding of the hemodynamic and physiological response to chest compression should improve automatic CPR devices. More accurate measuring devices and controllers could adapt the massage to the patient's rib cage stiffness or clinical presentation, increasing safety during robotic CPR [16].

Physiological outcomes

Tension pneumothorax, pneumomediastinum, myocardial injury, and liver rupture during CPR may lead to iatrogenic in-hospital mortality21. Inappropriate compression force or pressure can cause rib fracture or soft tissue injury. The compression pad's sensor may detect dangerous signals and remind rescuers to stop mechanical compressors between the myocardium and skeletal structure. Incorrect chest compression positions can cause fractures, so feedback is needed. The skin conductance sensor can detect the skin parameter during compression and analyze the tissue, distinguishing between the heart and rib. Customized CPR will be optimal in the future [20]. This study tested how well a parallel deceiver delivers cardiopulmonary resuscitation at the right rate and depth. Simulations and experiments showed that a novel 3-RRR parallel manipulator can deliver 100-120 compressions/min and 38–51mm of compression depth during CPR without human effort [19].

Survival(hospital/discharge/30-days)

Survival has enhanced over the last century due to public awareness campaigns, CPR training, public access defibrillators, EMS organizational improvements, and post-resuscitation care. A review has found 40% average survival rates to hospital discharge with early PAD [12]. The simultaneous manipulator reduces patient risk while reducing rescuer workload. It has a 3-RRR parallel manipulator with 30-80° motors. This allows the simultaneous manipulator to accomplish the 2010 compression rate and depth. The proposed manipulator improves the possibility of surviving heart attack with minimal risk to the patient and rescuer effort [19].

CPR by a robot

A robot should call for help and upload patient data to a medical professional so it can be remotely controlled to provide first aid, but in the future it could also act based on recognition results. This includes chest compressions, moving the person's chin up for a better airway, giving CPR if breathing is agonal or treating shock if indicated by breathing, and preventing bleeding by cooling injuries, compressing and elevating, or in an extreme case, applying a tourniquet [21]. This paper discusses AI in medical robots. Computer vision is used to manipulate and interpret medical images [22].

Robots for first aid

Moment and Living Tomorrow built a flying drone to carry medical equipment like a defibrillator to an emergency scene. How humans fall hasn't been studied, but it could affect injuries and emergency response. Chest compressions could worsen a chest injury and have serious consequences [21].

Conclusions

A life-saving procedure necessitates quick and effective ways to save patients' lives. Using robots and artificial intelligence. The ability of the system to accommodate patient features, potential changes in pressure resistance caused by tissue heating, and avoid rib rupture caused by the application of excessive force will all improve the efficiency of the outcome during CPR in hospitals. Which may reduce the risk and effort of doctors to save patients to protect the patient's ribs and heart, and most importantly has created a device that can reduce the risk of saving patients compared to traditional CPR, making it easier to perform CPR at the correct rate and time. Depth may also conclude that it aided the health system in avoiding collapse. It is safe, affordable, and accessible in real time, and more precise instrumentation and controls can adapt the massage to the rigidity of the patient's rib cage or clinical presentation, increasing safety during automated CPR. The future because the proposed therapist increases the chances of surviving a heart attack with minimal risks to the patient and the rescuer's efforts.

Ethical approval

Non

Abbreviations

KSA: Kingdom of Saudi Arabia
CPR: Cardiopulmonary Resuscitation
MOH: Ministry of Health
ADA: American Dental Association

Data Availability

On request

Acknowledgments

Not applicable

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Conflict of interest statement

The authors declare that there is no conflict of interest.

Author contributions

Conceptualization: HSBT, AAA, and KTA. Methodology: HSBT and AAA. Writing - Original Draft Preparation: KTA and HSBT. All contributors reviewed the manuscript.

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