

Systematic Review on the efficiency of prefilled syringe : To administer medication for cardiac arrest patient

¹Yoon Byoung Gil, ²Park Jung Hee, ³Kim Young Seo

^{1,2,3}Assist Prof. Dept. of Emergenct Medical Service Konyang University
ybksky@Konyang.ac.kr, jhpug@konyang.ac.kr, ys031113@konyang.ac.kr

Abstract

The Pulpose of this systematic review is aimed to establish the procedure of the injection with saftey and efficiency in the pre-hospital cardiac arrest patient performing the cardiopulmonary resuscitation (CPR), compared with traditional medication administration using Ampoule and medication administration with Pre-filled Syringe.

Databases were searched for CPR, heart arrest, resuscitation, Pre-filled Syringe, and Ampoule by the electronic data research including Pubmed, EMBASE and Cochran Library of Konyang University Library: 4 articles were selected by three co-authors using EndNote X20 and Covidence (Covidence.org) and were systematically reviewed.

The Result of this study, the medication administration using Pre-filled Syringe improves the safety of patients and Emergency medical workers by reducing the error in administration dose and administering the drug in safe than the medication adminisrtaion using Ampoule, also, contributes to the increment of survival rate of cardiac arrest and severe patients by decreasing the administration time that prevents the delay of medication administration.

Keywords: Ampoul, Pre-filled Syringe, Cardiac Arrest, Medication

1. INTRODUCTION

Epinephrine, a vasoconstrictor, is administered to increase cardiac output and blood pressure of the cardiac arrest patient and to improve the perfusion of brain and heart. For the treatment of refractory ventricular fibrillation and of pulseless ventricular tachycardia among the cardiac arrest electrocardiogram rhythms, Antiarrhythmics such as Amiodarone or Lidocaine is used to improve the Recovery of Spontaneous Circulation (ROCS) and survival admission rates [1-6].

To inject epinephrine, A drug stored in Ampoule like Figure 1 is transferred to a syringe, and 20 ml of normal saline is additionally injected to quickly reach the central circulation when the drug is administered to a peripheral vein after epinephrine bolus injection. Under the current circumstance, administration in order with 3 way cock valve as in Figure 2 is educated to quickly perform multiple-step administration [6].

Manuscript received: November 19, 2022 / revised: November 30, 2022 / accepted: December 9, 2022

Corresponding Author: ybksky@konyang.ac.kr

Tel: +82-42-600-8459, Fax: +82-42-600-8408

Professor, Dept. of Emergency Medical Service, Konyang Univ., Korea

Copyright©2022 by The International Promotion Agency of Culture Technology. This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0>)

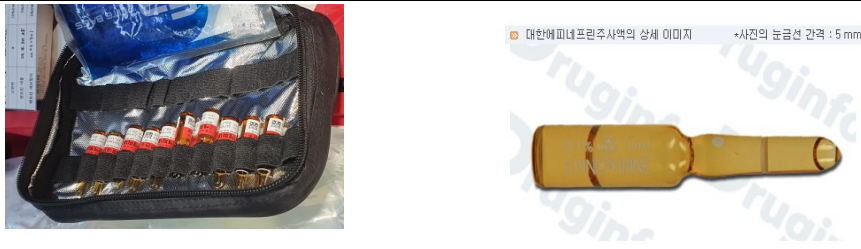


Figure 1. 119 Ambulance Drug

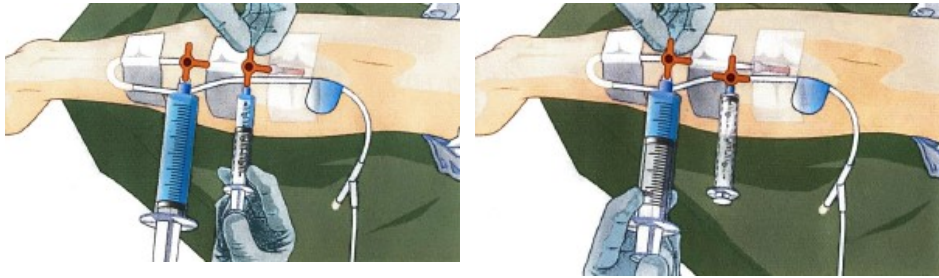


Figure 2. Administration in order with 3 way cock valve

Amiodarone, which gives medication as antiarrhythmics, is administered by diluting in 5% glucose solution or normal saline 20-30 ml because the undiluted solution is very sticky. Amiodarone is also used by diluting the drug stored in Ampoule after transferring to a syringe [6].

These processes are so complicated and hamper the speed during CPR that is difficult to realize the 6R principles: Right patient, Right medication, Right dose, Right route, Right time, and Right documentation, which are the basic principles of medication administration. In addition, stab wound is more likely cause in the very urgent case of emergency, because common injury to emergency medical workers is needle stabbing. Especially, with 1mg of epinephrine injection every 3 to 5 minutes of repeated-dose, a great need is required for improvement to administer safely and easily [7].

Since injectable drugs stored in Ampoule may cause side effects due to glass fragment when cutting containers, Ampoule should be carefully opened and minimize the incorporation of glass fragment, and transferring drugs from a glassed Ampoule to the syringe in a moving ambulance may impact the safety of 119 paramedics. Therefore, there is need of systematic review for the contribution to the improvement of the survival rate of patients with cardiac arrest, by securing 119 paramedics and by injecting safely and quickly through the development and dissemination of new products to make a safe administration.

Epinephrine pre-filled syringe 1:10,000 (Item Reference Code: 8806646023203, Standard Code: 8806646023203, 8806646023210) has been developed but is not being distributed [8]. We establish this study to safely and accurately administer drugs to the cardiac arrest patient during the pre-hospital cardiopulmonary resuscitation(CPR) in this systematic review.

2. PURPOSES

2.1 The Title of Each Section

This study was built to find out the way to administer safely and efficiently when performing CPR to Pre-hospital cardiac arrest patient.

The PICO questions to achieve the specific goal of the study are as follow:

P(Problem) : A cardiac arrest patient in pre-hospital.
 I(Intervention) : Than the medication administration using Ampoule.
 C(Comparison) : The medication administration using Pre-filled Syringe.
 O(outcome) : administer the drug safely and efficiently.

3. METHODS

3.1 Data Collection

Databases were searched for CPR, heart arrest, resuscitation, Pre-filled Syringe and Ampoule by the electronic data research including Pubmed, EMBASE and Cochran Library in Konyang University Library and the results of the study were utilized.

We aimed to the study on the full text and focuses on the safety and efficiency of the medication administration method among the retrieved data.

3.2 Study Selection

Studies fitting purposes were selected by transmitting articles researched in the academic searching site to EndNoteX20 program. Articles selected in EndNoteX20 program are imported into Covidence(Covidence.org), and three reviewers include studies that suit their goals, if not, the studies are exported to implement systematic review.

Selected articles evaluate the evidence level of the study and perform meta-analysis using the Revmen program, if necessary.

As Figure 3 Shows, 236 papers were found in the first search, 43 papers were selected by reviewing the title and abstract of articles, and 4 articles were included by screening articles suitable for the inclusion criteria by three authors using the Covidence program.

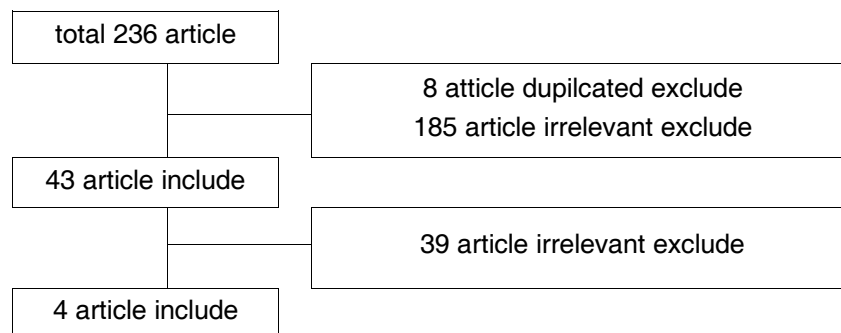


Figure 3. PRISMA flow diagram

3.3 Analyzed Data and Methods

A) Level of Evidence and Major Variable of Study

The five-step analysis classification method of the evidence level presented by M. H. Murad, N. Asi, M. Alsawa, F[9]) was applied as the evidence level of the analysis object, and according to the level of evidence, Level I (Systematic Review, Meta-Analysis), Level II (Randomized Controlled Trial), Level III (Cohort Study), Level IV (Case Control Studies), and Level V (Case Series/Report) were classified and major variables were analyzed.

B) Analysis of safety and rapidity

Meta-analysis was conducted by the Review Manager 5.4.1 program on the safety and rapidity of medication administration using Ampoule and Pre-filled Syringe in the finally included articles.

4. RESULTS

4.1 Level of Evidence and Major Variable Analysis

The level of evidence(LOC) of the study utilized in analysis was Randomized Controlled Trial(RCT) in all 4 (100%), and the analysis results of major variables according to the medication administration method of the analysis subjects were 4 (100%) preparation time for medication administration as shown in Table 1, and 2 (50%) errors in drug dose according to the medication administration method (Table1).

Table1. Level Of Evidence(LOE) and Major Variable Analysis

Author(yr)	LOE	Drug preparation time	Drug dose error
N. Castle (2010)[10]	II	•	
R.M. Adapa (2012)[11]	II	•	
A.D. Stevens (2015)[12]	II	•	•
M.E. Moreira (2015)[13]	II	•	•

4.2 Medication Preparation Time

With a total 80 of emergency nurses, nursing instructors, paramedics, paramedic instructors, paramedic students treated with two types of Pre-filled Syringes (Aurum Pre-filled Syringe and Miniject Pre-filled Syringe) and the other two types of Ampoule (Plastic Ampoule and Glass Ampoule) equipping CBRNE - PPE, medication preparation using Pre-filled Syringe was faster than Ampoule (p-values < 0.001) and quickly administer to patients without delay [10].(Table 2, Fig 2)

In the simulation trial administering vasoconstrictor to pulmonary edema patients with forty-eight nurses participating in the randomized, blinded and controlled study methods, the Pre-filled Syringe was 157 seconds (IQR 107-195 sec.), on the other hands Ampoule showed 260 seconds (IQR 211-334 sec.) during the preparation of Norepinephrine administration (P,0.001). In Epinephrine preparation, The Pre-filled Syringe was 147 seconds (IQR 107-180 sec.), whereas the preparation with Ampoule took 278 seconds (IQR 235-311 sec.) (P,0.001). And administration preparation with Ampoule took 106 seconds (96% CI 72-140 sec.), which was longer than administration preparation with Pre-filled Syringe [11]. (Table 2, Figure 2)

In a trial progressed by prospective, block-randomized, crossover study methods with a team of emergency medical workers and nurses assigned to 10 teams based on the infant cardiac arrest simulation scenario in the emergency room, the group using Pre-filled Syringe was 19 seconds (95% CI:18-20) and the other group using Ampoule was 47 seconds (95% CI:40-53)(Difference = 27[96% CI-33] sec.) [13]. (Table 2, Figure 2)

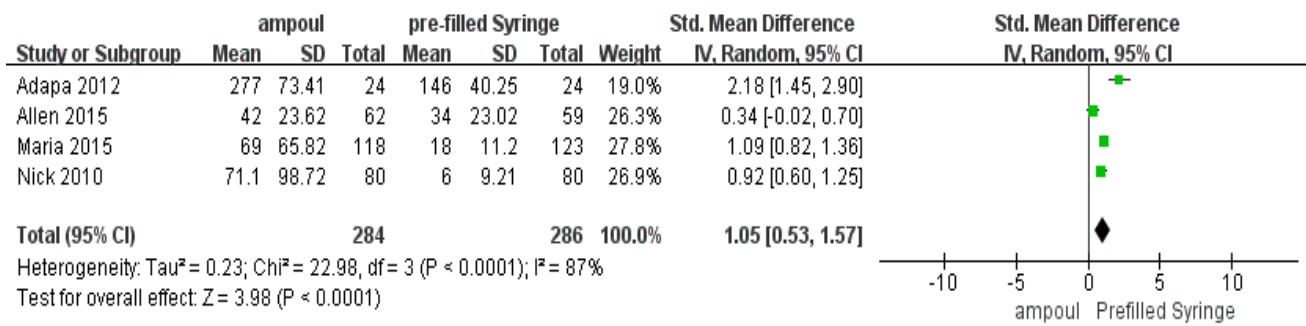


Figure 2. Drug preparation time forest plot

4.3 Medication Administration Error

In the same trial conducted by prospective, block-randomized, crossover study methods based on the pre-hospital infant cardiac arrest simulation scenario and composed of 10 teams of emergency medical workers and nurses, Ampoule administration resulted in a significant dose error of 24 (39%) in 62 doses and 0 (0%) in 59 doses using the Pre-filled Syringe method (Difference = 39%, 95% CI: 13–61%) [12]. (Table 2, Figure 3) In a prospective, clock-randomized, crossover study-method trial set in Infant cardiac arrest simulation scenario in the emergency room consisting of 10 teams of one emergency medical specialist and one nurse, 20 critical dosing errors (17%) of 118 doses took place in Ampoule administration, 0 dose errors (difference 17%; 95% CI 4%-30%) with 123 doses occurred in use of pre-filled syringe, that is, the use of pre-filled syringe administers safely without any errors in drug dose during pre-hospital and in-hospital pediatric resuscitation[13]. [Table 2, Fig. 3]

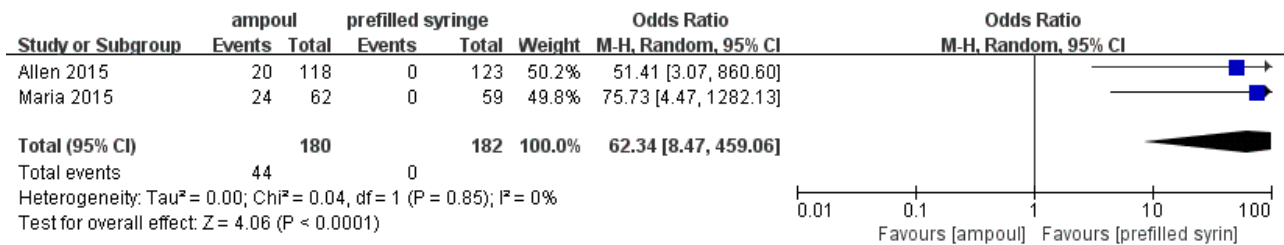


Figure 3. Drug dose error forest plot

5. DISCUSSION

This systematic review is aimed to rapidity and safety of the administration method for the drug safekept in the present Ampoule being prepared in syringe and the method for using Pre-filled Syringe to find the way of safe and effective medication administration in pre-hospital cardiopulmonary resuscitation (CPR) to cardiac arrest patient.

As a result of the analysis, the method using Pre-filled Syringe had a shorter time for medication administration than Ampoule and quickly administered to severe patients such as cardiac arrest patients.

2020 Korean Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care shows that 6 minutes of Basic Life Support (BLS) is performed to pre-hospital cardiac arrest patients on site, and transportation after on-site Advanced Cardiac Life Support (ACLS) for 10 minutes is recommended, if Advanced Cardiac Life Support (ACLS) including Epinephrine administration is applicable, then Pre-filled Syringe can be used to prepare the drug in a short period of time, which may contribute to improving the

resuscitation rate of patients with cardiac arrest [14].

Secondly, the analysis shows that Pre-filled Syringe method had fewer drug dose errors in medication administration than Ampoule Method. One of the basic principles of medication administration is to administer at the right dose. In some drugs, if the dose of drug is changed, the effect of drug may differ and the desired effect is not achieved.

The pilot study was at one with this study that unnecessary dilution which has been done conventionally may lead to inaccurate doses and possible contamination of the medication, but the use of Pre-filled Syringe reduces error in medication administration, such as errors and contamination of the drug, administering safely [15].

In addition, the use of Pre-filled Syringe has advantages such as right dosing and shortened dosing time including increase in patient convenience, and is one of the most effective ways to reduce drug errors in nurse medication administration [16-17]. Side effects such as stabbing on a needle or laceration of a finger on a glass were also reported during the preparation of medication administration using Ampoule while wearing CBRNE-PPE [10], and in searching for pharmaceuticals, warnings of drugs stored in Ampoule that causes side effects due to the incorporation of fragments as cutting the container informs to be carefully cut and use not to harm the safety of the patient [8]. Therefore, the use of Pre-filled Syringe improves, not only in patient safety, but also in the safety of emergency medical workers who administer drugs.

As mentioned above, medication administration with Pre-filled Syringe makes a contribution in increasing safety of patients and improving the survival rate of out-of-hospital severe patients by decreasing the errors in administration and the delay in advanced life support.

Whereas the concern about rising expenditures is expected because of Pre-filled Syringe which is not being generally disseminated in worldwide yet [10], the use of Pre-filled Syringe is recommended that patient safety, rapid administration, saving of technicians' time in administering, management cost reduction, and improvement in safety offset the concern mentioned above [18].

6. CONCLUSIONS

The medication administration of Pre-filled Syringe improves the safety of patients and paramedics by reducing errors in drug dose and safely administering drugs compared to the use of Ampoule, and contributes to the improvement of the survival rate of patients with cardiac arrest and severe diseases by preventing the delay of drug administration by reducing the administration period.

REFERENCES

- [1] I. G. Jacobs, J. C. Finn, G. A. Jelinek, H. F. Oxer, P. L. Thompson. Effect of adrenaline on survival in out-of-hospital cardiac arrest: A randomised double-blind placebo-controlled trial. *Resuscitation*. Vol. 82, No. 9, 1138-43, 2011
- [2] S. Petrou, N. Stallard, S. Gates, R. Lall, For the PARAMEDIC2 Collaborators. A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest. *N Engl J Med*. Vol. 379, No. 8, 711-21, 2018.
- [3] P. J. Kudenchuk, S. P. Brown, M. Daya, T. Rea, G. Nichol, L. J. Morrison, et al. Amiodarone, lidocaine, or placebo in out-of-hospital cardiac arrest. *N Engl J Med*. Vol. 375, 1711-22, 2016.
- [4] P. J. Kudenchuk, M. Daya, P. Dorian. Resuscitation outcomes consortium I. Amiodarone, lidocaine, or placebo in out-of-hospital cardiac arrest. *N Engl J Med*. Vol. 375, 802-3, 2016.
- [5] P. J. Kudenchuk, L. A. Cobb, M. K. Copass, R. O. Cummins, A. M. Doherty, C. E. Fahrenbruch, et al. Amiodarone for resuscitation after out-of-hospital cardiac arrest due to ventricular fibrillation. *N Engl J*

Med. Vol. 341, 871–8, 1999.

- [6] H. h, OH, K. C. Cha, J. H. Lee, D. H. Kim, B. K. Lee, J. S. Park. et al. 2020 Korean Guidelines for Cardiopulmonary Resuscitation. Part 4. Adult advanced life support. Clin Exp Emerg Med. Vol. 8, No. S, 26-40, 2021.
- [7] Korean Council of Professors for Emergency Medical Service. Management of Emergency Patient 5th edition. Seoul: Daehakseorim, 338-355.
- [8] Ministry of Food and Drug Safety. Available at: <https://nedrug.mfds.go.kr/index>
- [9] M.H. Murad, NIV. Asi, M. Alsawas, F. Alahdab. “New evidence Pyramid”, Evid Based Med. Vol. 21, No. 4, 125-127, 2016. <http://dx.doi.org/10.1136/ebmed-2016-110447>
- [10] N.Castle, J. Bowen, N. Spencer, Does wearing CBRN-PPE adversely affect the ability for clinicians to accurately, safely, and speedily draw up drugs? Clin Toxicol (Phila). Vol. 48, No. 6, 522-527, 2010. DOI: 10.3109/15563650.2010.491483
- [11] R. M. Adapa, V. Mani, L. J. Murray, B. A. Degnan, A. Ercole, B. Cadman et.al, Errors during the preparation of drug infusions: a randomized controlled trial. British Journal of Anesthesia. Vol. 109, No. 5, 729–34, 2012. doi:10.1093/bja/aes257
- [12] A. D. Stevens, C. Hernandez, S. Jones, M. E. Moreira, J. R. Blumen, E. Hopkins et.al. Color-coded prefilled medication syringes decrease time to delivery and dosing errors in simulated prehospital pediatric resuscitations: A randomized crossover trial. Resuscitation. Vol. 96, 85–91, 2015. DOI: 10.1016/j.resuscitation.2015.07.035
- [13] M. E. Moreira, C. Hernandez, A. D. Stevens, S. Jones, M. Sande, J. R. Blumen, Color-Coded Prefilled Medication Syringes Decrease Time to Delivery and Dosing Error in Simulated Emergency Department Pediatric Resuscitations. Ann Emerg Med. Vol. 66, No. 2, 97–106, 2015. DOI: 10.1016/j.annemergmed.2014.12.035
- [14] Korea Disease Control and Prevention Agency. 2020 Korean Guideline for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. 133-148. 2020
- [15] D. D. Degnan, T. N. Bullard, M. B. Davis, Risk of Patient Harm Related to Unnecessary Dilution of Ready-to-Administer Prefilled Syringes: A Literature Review. J Infus Nurs, Vol. 43, No. 3, 146–154, 2020. DOI: 10.1097/nan.0000000000000366
- [16] A. R. Kafal, D. C. Vinh, M. J. Langelier, Prefilled syringes for immunoglobulin G (IgG) replacement therapy: clinical experience from other disease settings, Expert Opin Drug Deliv, Vol. 15, No. 12, 1199–1209, 2018. DOI: 10.1080/17425247.2018.1546692
- [17] Z. Mohanna, S. Kusljic, R. Jarden, Investigation of interventions to reduce nurses' medication errors in adult intensive care units: A systematic review. Aust Crit Care, Vol. 35, No. 4, 466–479, 2021. DOI: 10.1016/j.aucc.2021.05.012
- [18] *Expert Rev.* Vaccine presentation in the USA: economics of prefilled syringes versus multidose vials for influenza vaccination. *Vaccines*, Vol. 9, No. 11, 1343–1349, 2021.