ISSN 2706-6819 Vol.4, Issue 9: 51-57, DOI: 10.25236/IJFM.2022.040910

Research on the Application Effect of RCA Combined with PDCA Quality Management on Improving the Management Quality of Pre-Hospital Emergency Equipment

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Abstract: Object: *To explore the application effect of RCA combined with PDCA quality management on improving the management quality of pre-hospital emergency equipment.* ***Methods:*** *The pre-hospital emergency equipment equipped with four ambulances in the Pre-hospital Emergency Department of a hospital in Xi'an was divided into the experimental group and the control group. The pre-hospital emergency equipment in the control group adopted the conventional management method, while the pre-hospital emergency equipment in the experimental group adopted the quality management method of RCA combined with PDCA. The quality management effect of pre-hospital emergency equipment was compared between the two groups.* ***Results:*** *In the comparison of management quality of pre-hospital emergency equipment, the incidence of insufficient oxygen in cylinders and the incidence of not fully charged pre-hospital emergency equipment of the experimental group decreased significantly than that of the control group ($\chi2=4.688$,$\chi2=5.838$; $P<0.05$), the ratio of all pre-hospital emergency equipment passed in one inspection of the experimental group was significantly increased ($\chi2=5.128$; $P<0.05$), which reached 100%. In comparison of work hand-over management time of ambulances, the work hand-over management time of the experimental group was significantly lower than that of the control group ($t=4.677$; $P<0.001$).* ***Conclusions:*** *In the management of pre-hospital emergency equipment, RCA combined with PDCA quality management method can significantly improve the management quality of pre-hospital emergency equipment, and significantly improve the quality and efficiency of work hand-over management of ambulances. RCA combined with PDCA quality management has a significant effect on improving the quality of pre-hospital emergency equipment management.*

Keywords: *RCA; PDCA; pre-hospital emergency equipment; management quality*

1. Introduction

Pre-hospital Emergency Department is a medical management unit that rescues critically ill patients and transfers them to the corresponding departments of medical institutions for further treatment. It is an important part of the first aid system and plays an important role in the process of coping with various public emergencies, disaster rescue and rescuing critically ill patients [1]. Pre-hospital emergency equipment has been used with ambulances in the process of out-of-hospital transport of patients. In the process of out-of-hospital transport, the road might be long, the road might be crowded and the emergency task is usually urgent, which makes the pre-hospital emergency medical equipment prone to malfunction, affecting the treatment safety. The particularity of pre-hospital emergency task requires that effective measures should be taken to improve the management quality of pre-hospital emergency equipment.

RCA (Root Cause Analysis) is a retrospective research method. Through systematic investigation and research on the problems that have occurred, the root causes of the problems are found out, and corresponding improvement measures are formulated. The method was originally used in quality management in the aviation and industrial fields to find out the causes of errors and correct them [2,3].

ISSN 2706-6819 Vol.4, Issue 9: 51-57, DOI: 10.25236/IJFM.2022.040910

In recent years, it has also been gradually applied to medical management for the cause analysis of adverse events.

PDCA is the most commonly used quality improvement method in enterprise management. It divides quality management into four stages: P (Plan), D (Do), Check (C), and A (Action).It requires that a plan is first formulated in the quality work, and then the tasks are executed according to the plan, and then the execution process is checked, and the good parts found in the inspection are reserved, and the parts that need to be rectified are implemented in the next cycle[4-6].PDCA is the basic method of quality management. In this study, the effect of RCA combined with PDCA quality management on the management of pre-hospital emergency equipment was analyzed to verify the effectiveness of this method in the management of pre-hospital emergency equipment.

2. Research Materials and Methods

2.1. General Materials

The Pre-hospital Emergency Department of a hospital in Xi'an has 4 ambulances, equipped with medical equipment including: monitors, defibrillators, electric sputum suction devices, cardiopulmonary resuscitation devices, infusion pumps, syringe pumps, transfer ventilators, blood glucose meters, blood pressure monitors, stethoscopes, thermometers, etc., a total of 124 sets. All the above medical devices were used as research materials in this study. In this study, the pre-hospital emergency equipment was divided into the experimental group and the control group by ambulance. The experimental group included the medical equipment equipped with two ambulances, and the medical equipment in the experimental group was managed by RCA combined with PDCA quality management, while the control group included the medical equipment equipped with another two ambulances. The medical equipment in the control group was managed by conventional management methods. During the study period, the medical equipment in each ambulance was required to be centrally managed by ambulance, and these medical equipment cannot be interchanged between different ambulances.

2.2. Research Methods

For the medical equipment management of the experimental group, firstly, RCA was used to find out the root causes of the high failure rate of medical equipment, and improvement measures were formulated, and then PDCA cycle was used to promote the implementation of improvement measures.

2.2.1. Set Up the RCA-PDCA Team

The RCA-PDCA team consisting of head nurse, nurse in charge and engineer of medical equipment management department was established. The management team is responsible for the management of the whole management process. The management team firstly studied the management methods of RCA and PDCA, formulated the RCA-PDCA management process in line with the actual situation of the department, conducted RCA-PDCA training for general medical staff, and summarized the low management quality of pre-hospital emergency medical equipment.

2.2.2. Finding the Proximal Causes

The phenomenon of high failure rate of pre-hospital emergency medical equipment was analyzed by referring to relevant literature and technical data and combining with the actual situation of the department. The proximal causes of low management quality of pre-hospital emergency medical equipment were obtained, including five aspects of Man, Machine, Material, Method and Milieu, which are as follows [7]:

(1) In terms of Man factors, medical staff were not skilled in the operation of emergency equipment. They didn’t have enough emergency equipment maintenance skills and didn’t adhere to the daily cleaning and maintenance of the equipment. Secondly, they didn’t carry out adequate inspection of the equipment, resulting in insufficient oxygen cylinders, insufficient battery power of the equipment, equipment accessories damage, etc. Thirdly, medical staff didn’t handle the equipment with care, resulting in frequent violent collision and damage of the emergency equipment. In addition, clinical medical engineers did not carry out timely preventive maintenance of emergency equipment, resulting in the hidden danger of the equipment was not found in time, which finally caused serious failure.

(2) In terms of Machine factors, firstly, the reliability of pre-hospital emergency equipment is insufficient, and it didn’t have enough performance of anti-vibration, anti-fall, waterproof, dustproof and

ISSN 2706-6819 Vol.4, Issue 9: 51-57, DOI: 10.25236/IJFM.2022.040910

anti-electromagnetic interference. Secondly, emergency equipment was not well fixed in the ambulance, which was easy to cause the medical equipment to break down due to the bumpy road in the process of transporting patients. Thirdly, some emergency equipment was too large in volume and weight, which made it difficult for medical staff to move it, and it was easy to fall and cause equipment failure.

(3) In terms of Material factors, first of all, there was a lack of necessary equipment maintenance tools in the ambulance carrying out the transfer task, which led to the failure to timely deal with screw loosening and other situations in the process of transfer. Secondly, the lack of consumables preparation led to the shortage of consumables in the transshipment process.

(4) In terms of Method factors: First of all, the management process system of pre-hospital first aid equipment was not perfect, resulting in medical staff not insisting on cleaning and checking the equipment every day, and the daily management and maintenance responsibilities of pre-hospital emergency equipment were not implemented in place. Secondly, the lack of preventive maintenance system of equipment led to clinical medical engineers not timely preventive maintenance of pre-hospital emergency equipment.

(5) In terms of Milieu factors, the main use milieu of pre-hospital emergency equipment was in the ambulance. The space on the ambulance was narrow, the equipment was crowded, the road was prone to turbulence, the power supply and air source might be unstable, and the ambulances were not cleaned in time, which all easily led to a high failure rate of equipment.

2.2.3. Discovering the Root Causes

The RCA-PDCA team analyzed the proximal causes of the low management quality of the above pre-hospital emergency equipment, then they conducted brainstorming discussion, and determined the root causes of the low management quality of the pre-hospital emergency equipment according to the 80/20 rule [8]:(1) medical staff didn't pay enough attention to the management of pre-hospital emergency equipment; (2) the training in equipment operation and maintenance was not in place, which led to the misoperation of medical staff and the lack of skills in basic maintenance of pre-hospital emergency equipment; (3) the hospital lacked the management process system and preventive maintenance system of pre-hospital emergency equipment, which led to the lack of constraints and guidance on the management behavior of pre-hospital emergency equipment by medical staff and clinical medical engineers; (4) the actual use milieu should be taken into account in the purchase of pre-hospital emergency equipment; (5) the equipment maintenance skills of clinical medical engineers were insufficient.

2.2.4. Determine Improvement Measures

According to the above root causes, the following improvement measures were determined by referring to the relevant literature at home and abroad:(1) medical staff should be educated on the importance of pre-hospital emergency equipment management and crisis awareness, so as to improve their attention to pre-hospital emergency equipment management; (2) medical staff should be trained on the operation and maintenance of pre-hospital first aid equipment to strengthen their skills;(3) carry out higher circuit board-level equipment maintenance training for clinical medical engineers, and make sure that clinical medical engineers have deeper skills in emergency equipment maintenance; (4) establish the management process of pre-hospital emergency equipment for medical staff and the preventive maintenance system of pre-hospital emergency equipment for clinical medical engineers; (5) equip the ambulances with necessary equipment maintenance tools for emergency equipment maintenance; (6) establish guidelines for the purchase and selection of pre-hospital emergency equipment. In the procurement stage of pre-hospital emergency equipment, the actual situation of first aid transfer should be considered. The emergency equipment purchased should firstly have the performance of anti-vibration, anti-fall, waterproof, dustproof and anti-interference. Secondly, the emergency equipment purchased should be as small as possible, light in weight, and easy to move. Thirdly, the functions of the selected emergency equipment should be as integrated as possible, and the operation should be as simple as possible. In addition, the selected equipment should also have the networking function, which can timely transmit the acquired patient examination data to other devices for analysis.

2.2.5. P-Plan Stage

For the above improvement measures, the implementation schedule was formulated in the planning stage of PDCA to promote the implementation of the measures, mainly including: (1) Formulate the time schedule of pre-hospital emergency equipment operation and maintenance training for medical staff; (2) Develop the training schedule of emergency equipment maintenance for clinical medical engineers; (3)

ISSN 2706-6819 Vol.4, Issue 9: 51-57, DOI: 10.25236/IJFM.2022.040910

Develop the preventive maintenance schedule for clinical medical engineers; (4) Establish a daily management list of pre-hospital emergency equipment for medical staff, including the management of the equipment itself and the cleaning of the ambulances[9].

2.2.6. D-Do Stage

In Do Stage, medical staff and clinical medical engineers should strictly implement the contents of the plan, mainly including :(1) the implementation of various training plans; (2) the implementation of the daily management list of medical staff; (3) the implementation of preventive maintenance system for clinical medical engineers; (4) when purchasing new emergency equipment, it is necessary to refer to the pre-hospital emergency equipment procurement and selection guidance; (5) preparation of emergency maintenance tools on the ambulance.

2.2.7. C-Check Stage

The RCA-PDCA team carried out irregular inspections to check the implementation of the plan and recorded the results of the inspections.

2.2.8. A-Action Stage

RCA-PDCA team held the RCA-PDCA quality summary meeting, summarized the problems found in the inspection, discussed the rectification measures, and implemented the rectification measures in the next round of PDCA cycle [10].

2.3. Assessment Indicators

2.3.1. Comparison of Management Quality of Pre-hospital Emergency Equipment between Two Groups of Ambulances

The management quality of pre-hospital emergency equipment in 30 days before performing tasks between the experimental group and the control group was compared, including the total times of tasks performed by the ambulance, the times of insufficient oxygen in cylinders, the times of not fully charged pre-hospital emergency equipment and the times of all pre-hospital emergency equipment passed in one inspection.

2.3.2. Comparison of Work Hand-over Management Time between Two Groups of Ambulances

The work hand-over management time of ambulances in 30 days between the experimental group and the control group was statistically compared, so as to verify the effect of RCA-PDCA management measures on improving the management efficiency of pre-hospital emergency equipment.

2.4. Statistical Analysis

The above data were input into EXCEL and imported into SPSS20.0 software for processing, where count data were represented by [N (%)] and analyzed by Chi-square test, measurement data were represented by $\bar{x} \pm s$ and analyzed by t test, and $t<0.05$ indicated statistically significant differences.

3. Results

3.1. Comparison Results of Management Quality of Pre-hospital Emergency Equipment between Two Groups of Ambulances

The comparison results of management quality of pre-hospital emergency equipment between two groups of ambulances are shown in Table 1 below. It can be concluded that the incidence of insufficient oxygen in cylinders and the incidence of not fully charged pre-hospital emergency equipment of the experimental group decreased significantly than that of the control group (χ^2=4.688,χ^2=5.838; P<0.05), the ratio of all pre-hospital emergency equipment passed in one inspection of the experimental group was significantly increased (χ^2=5.128; P<0.05), which reached 100%.

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Table 1: Comparison of management quality of pre-hospital emergency equipment between two groups of ambulances [n (%)]

Group	n	Times of insufficient oxygen in cylinders	Times of not fully charged equipment	Times of all equipment passed in one inspection
Control group	257	18(7.00)	31(12.06)	245(95.33)
Experimental group	262	3(1.15)	9(3.44)	262(100.00)
$\chi 2$	-	4.688	5.838	5.128
P	-	0.030	0.016	0.024

3.2. Comparison Results of Work Hand-over Management Time between Two Groups of Ambulances

The comparison results ofwork hand-over management time between two groups of ambulances are shown in Table 2 below. On the premise of meeting the normality test, the independent sample t-test was carried out. It can be concluded that work hand-over management time of the experimental group was significantly lower than that of the control group (t=4.677; P<0.001). The comparison boxplot of work hand-over management time of ambulances between the two groups is shown in Figure 1 below, in which group 1 is the control group and group 2 is the experimental group. Outliers in group 2 represent the increase or decrease of management time caused by special reasons.

Table 2: Comparison of work hand-over management time between the two groups of ambulances [Time, ($\bar{x} \pm s$)]

Group	Days of record	Work hand-over management time
Control group	30	15.32±4.46
Experimental group	30	9.58±3.29
t	-	4.677
P	-	0.000

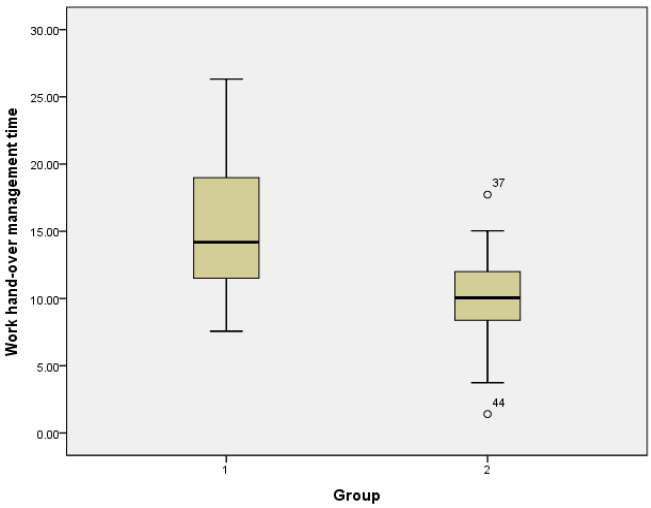

Figure 1: Boxplot of comparison of work hand-over management time between the two groups of ambulances

4. Discussion

With the improvement of modern medical level and the attention of modern society to the level of physical health, people are increasingly making emergency calls to get emergency treatment of critically ill patients [11]. In order to meet the treatment needs, there are more and more middle and high-end emergency equipment in the pre-hospital emergency department of the hospital, which play an important role in the process of treating patients. Due to the neglect of the management of pre-hospital emergency equipment, the equipment performance is unstable, the failure rate is high, and the treatment efficiency and medical safety are affected. In order to improve the management quality of pre-hospital emergency equipment, a hospital in Xi'an established the RCA-PDCA team to study the problems and phenomena

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in equipment management and found ways to solve them.

In this study, the hospital adopted the management method of RCA analysis combined with PDCA. Firstly, the RCA-PDCA team summarized the problems found, and found the proximal causes of such problems from five aspects of factors including Man, Machine, Material, Method and Milieu. Then they found the root causes of the problems through deep analysis. Furthermore, they formulated improvement measures. Finally, the PDCA cycle was used to promote the implementation of the measures. In the improvement measures, the medical staff received training in the operation and maintenance of pre-hospital emergency equipment. They cleaned and maintained the equipment every day, and checked the equipment according to the content of the daily management list. Meanwhile, clinical medical engineers also carried out preventive maintenance of pre-hospital emergency equipment in strict accordance with the schedule of preventive maintenance. As a result, in the comparison of management quality of pre-hospital emergency equipment, the incidence of insufficient oxygen in cylinders and the incidence of not fully charged pre-hospital emergency equipment decreased significantly after adopting RCA combined with PDCA quality management measures (2=4.688,2=5.838; P<0.05), the ratio of all pre-hospital emergency equipment passed in one inspection was also significantly increased ($\chi 2$=5.128; P<0.05), which reached 100%.At the same time, after adopting RCA combined with PDCA quality management measures, since medical staff insisted on cleaning and arranging pre-hospital emergency equipment every day. When medical staff handed over the work, the equipment was neatly placed and in good condition, which made work hand-over management time of ambulances decrease significantly (t =4.677; P<0.001). Quality management measures significantly improved the quality and efficiency of work hand-over management of ambulances. RCA combined with PDCA quality management has a significant effect on improving the quality of pre-hospital emergency equipment management.

5. Conclusions

In conclusion, RCA combined with PDCA quality management measures were adopted in the management of pre-hospital emergency equipment, medical staff carried out daily management of the emergency equipment, and clinical medical engineers insisted on preventive maintenance of the emergency equipment, which significantly improved the management quality of pre-hospital emergency equipment, and the ratio of all pre-hospital emergency equipment passed in one inspection reached 100%. At the same time, this management method made work hand-over management time of ambulances decrease significantly. It significantly improved the quality and efficiency of work hand-over management of ambulances. RCA combined with PDCA quality management has a significant effect on improving the quality of pre-hospital emergency equipment management.

Acknowledgements

This work was supported by grants from Innovation Capability Support Plan of Shaanxi Province (2017KCT-36), Natural Science Special Project of Shaanxi Province (2020SF-035), Social Development Project of Shaanxi Provincial Key Research and Development Program (2021SF-173).

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