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Application of the Quality Control Circle to Improve the Recording Accuracy of Fluid Intake and Output in Patients with Chronic Heart Failure

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Abstract

Volume management is a core component of clinical diagnosis and treatment in patients with heart failure. Accurate recording of fluid intake and output serves as a critical foundation for condition assessment and treatment planning. However, in clinical practice, the recording accuracy is often low due to problems such as inconsistent tools, nonstandard procedures and inadequate education, and there is a risk of misdiagnosis and treatment deviation. The purpose of this study is to systematically improve the accuracy of fluid intake and output records of hospitalized patients with heart failure through Quality Control Circle (QCC) activities. The Quality Control Circle (QCC), named the "resultant force circle", operated following the PDCA cycle and goes through ten steps, including theme selection, current situation investigation, goal setting, root cause analysis, countermeasure implementation and effect evaluation. According to the baseline survey, the accuracy of recording the fluid intake and output of patients with heart failure in April 2024 was 66.7%. Through Pareto analysis, the three main causes of "Information dependent on family memory", "Inconsistent measuring tools" and "Nurses' education is not in place" were identified, and 12 root causes were confirmed by fishbone diagram and true cause verification table. Aiming at the real cause, the team implemented comprehensive intervention from three aspects: process optimization, tool equipment and education and training. After the improvement, the sampling data shows that the accuracy rate is increased to 92%, the target achievement rate is 106%, and the progress rate is 38%. Intangible results show that the soft power of circle members' sense of responsibility, team spirit and self-confidence has been significantly enhanced. In addition, the project has realized the

establishment of the standardized flow of fluid intake and output records, and has applied for an invention patent on intelligent metering drinking water control. The research shows that quality control circle activities can effectively improve nursing quality, and its multi-dimensional collaborative improvement model has good sustainability and promotion value.

Keywords

Quality Control Circle, Heart Failure, Fluid Intake and Output, Nursing Quality, Continuous Improvement

1. Introduction

Heart failure is a complex clinical syndrome, and one of its core pathophysiological mechanisms is the increase of cardiac preload caused by body fluid retention. Therefore, accurate volume management is very important for stabilizing hemodynamics, relieving symptoms and preventing readmission [1]. As the most direct and basic index to reflect the daily fluid balance of patients, the accuracy of the records directly affects the doctor's judgment on key treatment decisions such as diuretic use and rehydration speed. Inaccurate records may lead to hypotension and renal function decline due to over-diuresis, or delayed treatment resulting from inadequate fluid replacement, and even become a potential cause of medical disputes.

Although the importance of fluid intake and output records has been widely recognized, its implementation still faces many challenges in actual clinical work. The existing research [2] [3] shows that the factors affecting the accuracy of records are complex and diverse, including poor compliance of patients and accompanying staff, lack of unified measurement tools, difficulty in converting food moisture content, and insufficient time for nurses to teach. Traditional management methods are mostly scattered reminders or verbal emphasis, lacking systematic and long-term mechanisms, and it is difficult to fundamentally solve problems.

As a quality management method originated from Japan, quality control circle has been widely used in domestic medical field in recent years, especially in nursing quality management. By organizing front-line employees to form groups, using scientific quality management tools and following PDCA cycle, it can independently discover and solve practical problems in work. This method emphasizes data-driven, full participation and continuous improvement, which can effectively stimulate the team's vitality and transform individual experience into a reproducible standard process. In view of this, taking the Department of Cardiology, the First Affiliated Hospital of Sun Yat-sen University as the practice base, this study carried out a quality control circle activity with the theme of "improving the accuracy of records of patients with chronic heart failure", aiming at exploring a scientific, standardized and sustainable path to improve nursing quality and

providing reference for similar problems.

2. Methods

2.1. Introduction of Circle Group

In this study, 10 nurses from the Department of Cardiology spontaneously formed a "resultant force circle". The name of the circle has profound implications, symbolizing that doctors and patients and team members are like hands clasped, working together to form a strong joint force to solve clinical problems. The circle emblem features a heart and a pair of clasped hands, symbolizing unity and collaboration, which intuitively embodies this concept. The circle leader is a senior nurse, who is responsible for the planning and coordination of the overall activities; Supervisors provide professional guidance and support for ward nurses. The members have an average clinical experience of 12 years. According to the ten steps of quality control circle, the team has a clear division of responsibilities: two people are responsible for current situation investigation and data collection; Two people are responsible for goal setting and calculation; Three people are responsible for root cause analysis and countermeasures; Three people are responsible for the specific implementation and follow-up of countermeasures; The effect check is completed by two people together; The final results arrangement and report writing are led by the circle leader and secretary. This division of labor ensures that each link has a special person in charge and ensures the efficient promotion of activities.

2.2. Theme Selection

The selection of the theme strictly follows the evaluation method. First, the team brainstormed, combined with the department's work priorities and patients' safety needs, and put forward 10 alternative themes, including "improving the accuracy of making medical orders", "improving the satisfaction of inpatients" and "reducing the missed charges of nursing projects". Then, score from three dimensions: importance, urgency and circle ability. Scoring criteria are: "importance" depends on the degree of higher-level policy requirements (5 points = repeated requirements, 3 points = requirements, 1 point = occasional requirements); "Urgency" depends on the urgency of problem solving (5 points = it can be solved, 3 points =3 - 6 months, 1 point = more than 6 months); "Circle ability" is based on the difficulty of problem solving (5 points = intra-department solving, 3 points = nursing department solving, 1 point = inter-department solving). After all the members scored independently, it was concluded that "improving the accuracy of records of patients with heart failure" ranked first with a total score of 147, and was determined as the theme of this activity. Its high score stems from the fact that the theme has great positive significance for hospitals (improving medical quality), patients (ensuring the safety of diagnosis and treatment) and nurses (enhancing their sense of responsibility), and it is completely within the ability of the undergraduate department.

2.3. Definition and Measurement Index of Terms

In order to ensure the rigor of the research, the core concepts are clearly defined in this study.

Fluid Intake: refers to the total amount of all liquids entering the patient's body, including drinking water, water content in food, intravenous infusion and blood transfusion.

Fluid Output: refers to the total amount of all liquids discharged from the patient's body, including urine volume, vomit volume, stool volume (solid output needs to be converted according to water content after weighing), gastrointestinal decompression volume and various drainage fluids (such as pleural effusion and ascites).

Accuracy of volume record: the core measurement index of this study, and its calculation formula is as follows:

"Accuracy" = "Correct recording times" / "Total recording times" × 100%

Among them, "correct recording" means that the recorded content is complete, the numerical value is accurate (such as measuring with a graduated container), and it is consistent with the actual situation.

2.4. Current Situation Investigation

In order to grasp the real situation of the problem, the team conducted a two-week status survey from April 1 to April 14, 2024. Inclusion criteria: (1) Acute exacerbation of chronic heart failure (AE-CHF) diagnosis; (2) NYHA class III - IV; (3) Ability to cooperate effectively. Exclusion criteria: (1) History of mental illness; (2) Severe comorbidities involving other vital organs. Type of ward: general cardiology inpatient ward. Enrollment method: Consecutive enrollment was used in both study phases. All patients who met the inclusion criteria and had no exclusion conditions were enrolled in sequence. The subjects were 96 case-episodes of chronic heart failure during this period. The survey tool is the 24-Hour Intake and Output Accuracy Audit Form, which including intake, output, and causes of errors. All QC team members received standardized training and were required to pass an assessment before participating in data collection. Data collection was performed using a combination of on-site inspection and interviews by QC team members to ensure data authenticity and reliability. Verification method: QC team members performed an item-by-item comparison between the recorded forms and their on-site observations (e.g., using graduated cups and measuring cups to actually measure the patient's intake and output). The survey results show that the accuracy of the current volume record is only 66.7% (64/96 × 100%). By classifying and counting 32 wrong records, the causes of five kinds of problems and their frequency distribution are preliminarily identified: a) Information depends on family members' memories (10 cases, 31%), b) Measurement tools are not uniform (8 cases, 25%), c) Nurses' education is not in place (7 cases, 22%), d) Items that are difficult to measure are omitted (5 cases, 16%) and e) Poor patient and family compliance (2 cases, 6%).

2.5. Goal Setting

Based on the survey results, the team set specific and quantifiable goals. The baseline value before improvement was 66.7%. Through team consensus, the "circle ability" of this quality control circle activity is 92.0% (46/50 × 100%). According to Pareto analysis, the cumulative proportion of the first three main causes (A, B and C) is 78%. Using scientific formula to calculate the target value:

"Target value" = 66.7% + [(1 − 0.667) × 0.78 × 0.92] × 100% ≈ 90.6%

As a result, the team set a SMART goal: by August 2024, through the quality control circle activities, the accuracy of the records of patients with heart failure will be improved to over 90.6%.

2.6. Root Cause Analysis

In order to dig deep into the root of the problem, the team first used Pareto for analysis. The results show that the cumulative percentage of three causes, A, B and C, reaches 78%, which conforms to the "80/20 rule" and is identified as the key minority that needs priority improvement. Subsequently, aiming at these three main causes, three fishbone diagrams were drawn from five dimensions: "Man, Machine, Material, Method, Environment", and 12 potential causes were sorted out. For example, the potential causes of "information-dependent family memories" include "no clear record process" and "lack of special record registration form". In order to avoid subjective assumptions, the team formulated the "Real Cause Checklist", and confirmed 12 potential causes one by one through the primary screening of "team consensus" and the secondary verification of "field investigation". In the end, all 12 factors were proved to be "real causes", including: lack of standardized process, lack of unified graduated cups, inconvenience in finding food moisture table, insufficient training of nurses, and no special measuring tool placement area [4].

2.7. Formulation and Implementation of Countermeasures

For 12 real causes, the team brainstormed, worked out specific and feasible countermeasures, and made clear the person in charge, the time and place of completion. The main countermeasures are divided into three categories:

The first category: process optimization

Aiming at the real causes of "no clear process" and "lack of registration form", the Standardized Process of 24-hour Inward and Outward Record of Patients with Heart Failure was formulated and published, and a special Inward and Outward Record Sheet was designed, which was placed at the end of patients' beds for easy filling.

Category II: Tools and equipment

In view of the real causes of "non-uniform tools" and "unknown areas", the department uniformly purchased a number of calibrated water cups and special electronic scales for food. At the same time, a special "measuring tool placement area" was set up on the nurse platform, and clear signs and instructions were pasted.

The third category: education and training

In view of the real causes of "insufficient education" and "single way", on the one hand, the entry and exit record norms are included in the pre-job training of new and rotation nurses [5] and assessed monthly; On the other hand, illustrated propaganda leaflets and easy-to-understand propaganda videos [6] were made, which were not only distributed when patients were admitted to the hospital, but also arranged to be played in the public area of the ward every morning, thus realizing diversified and high-frequency health propaganda.

The above countermeasures were fully implemented from July to August, 2024. During the implementation process, the circle leader will hold regular circle meetings to track the progress of various countermeasures and make timely adjustments according to the feedback to ensure that the measures come into effect.

3. Results

3.1. Tangible Results

After the intervention measures were implemented, the team conducted a sampling review of 25 case-episodes with heart failure in by the end of July 2024. The results show that the accuracy of the record of in-and-out volume is significantly improved from 66.7% before improvement to 92%. Based on this data, it is calculated that:

The target achievement rate = $(92 - 66.7)/(90.6 - 66.7) \times 100\% \approx 106\%$.

Progress rate = $(92 - 66.7)/66.7 \times 100\% \approx 38\%$

The improved Pareto shows that the frequency of the two problems, "Information dependent on family memory" and "Inconsistent measurement tools", which accounted for the highest proportion, has been greatly reduced, indicating that the previous intervention measures were accurate and effective.

In this activity, the pre- and post-intervention surveys were two independent cross-sectional investigations, rather than a pre-post comparison of the same study subjects. A baseline survey was conducted at the beginning of the project, which enrolled a total of 96 patient-episodes. After 4 months of the intervention, a convenience sample of 25 patient-episodes was drawn for the post-intervention assessment. The two sets of surveys were conducted at different time points, used independent sampling, and had no paired relationship; therefore, the sample sizes are different.

Statistical analysis: SPSS 26.0 software was used. The accuracy rate of intake and output recording was expressed as a percentage. Pre- and post-intervention comparison was performed using Fisher's exact test, with the significance level set at $\alpha = 0.05$.

Results: The baseline accuracy rate of intake and output recording was 66.7% (64/96), and the post-intervention accuracy rate was 92.0% (23/25). The difference was statistically significant ($P = 0.01 < 0.05$).

3.2. Intangible Achievements

In addition to tangible data improvement, the team's soft power has also been

significantly enhanced. Through anonymous rating (scored out of 10) by 10 circle members before and after the activity, the results show that many indicators have made significant progress. Among them, the sense of responsibility rose from 8.3 to 9.8, team spirit rose from 7.9 to 9.6, and self-confidence rose from 7.6 to 9.3. Communication ability, problem-solving ability and sense of honor have also been improved to varying degrees. These changes show that quality control circle activities not only solve specific problems, but also exercise the team and enhance cohesion and professional self-confidence.

3.3. Maintenance and Extension of Achievements

To ensure the sustainability of the results, the project has made the following substantive progress:

Efficiency improvement: due to the standardized process and complete tools, the time for nurses to check and record the amount of fluid intake and output each time has been shortened from about 3 minutes to 1.5 minutes, and the work efficiency has been significantly improved.

Standardization construction: The documents "Standardized Flow of 24-hour Fluid Intake and Output Records of Patients with Heart Failure" and "Standardized Training of Nurses' Professional Knowledge" have been officially released and incorporated into the routine management system of the department, realizing the transformation from temporary measures to long-term mechanisms.

Innovation and transformation: Based on the experience of this activity, the team has submitted an invention patent application to China National Intellectual Property Administration named "A Method and System for Drinking Water Control Based on Intelligent Metering for Patients with Heart Failure", which indicates that clinical practice is moving towards technological innovation.

4. Discussion

The successful implementation of the QCC method significantly improved the accuracy of fluid intake and output records in patients with heart failure and its successful experience is worth further discussion. First of all, the data-driven decision-making model is the key to success. Every step, from current situation investigation to goal setting to root cause analysis [7] [8], is based on objective data. In particular, Pareto is used to lock in a few key problems, so that limited resources can focus on the core contradictions and avoid the ineffective approach of "scattering efforts too thinly".

Secondly, the multi-dimensional collaborative intervention strategy ensures the depth and breadth of improvement [9]. This study is not limited to a single level of improvement, but from the "process", "tools" and "people" three dimensions at the same time. It not only solves the problem of lack of hardware (such as unified water cup and electronic scale), but also makes up for the deficiency of software (such as standardized process and diversified education), forming a closed-loop solution. This kind of systematic thinking is not available in traditional management methods.

Thirdly, the emphasis on long-term mechanism ensures the sustainability of the results. Many quality improvement projects are often "short-lived" and return to their original state at the end of the activity. This study ensures the long-term implementation of the new process by writing effective countermeasures into the SOP file of the department and establishing a regular training and assessment system. In addition, the application of invention patent transforms clinical wisdom into intellectual property, which greatly enhances the academic value and influence of the project.

Compared with similar research, this project is more forward-looking in information exploration. The research of Liu Kaili and others [10] mainly focuses on process optimization and education strengthening, and this project has taken the first step of intelligence. Of course, this study also has limitations: the sample size is small, only from a single center, and the long-term effect needs to be followed up for a longer time.

The future research direction should focus on the development of a mobile APP for recording the amount of incoming and outgoing, which can realize the functions of scanning the patient's code, automatically calculating the water content, uploading the data to the nurse station in real time, and setting up an early warning of abnormal values, so as to minimize manual intervention and realize real intelligent management [11].

5. Conclusion

Through the scientific application of the PDCA cycle, the QCC successfully increased the accuracy of fluid record documentation from 66.7% to 92%, achieving a target attainment rate of 106%. The activity not only realized the standardization and standardization of nursing operation, but also significantly improved work efficiency. More importantly, a sustainable quality improvement system was constructed through process reengineering, tool innovation and education and training. This model fully proves the strong vitality of quality control circle in solving clinical practical problems, and can be popularized and applied in other wards and even the whole hospital, which provides a powerful practical example for comprehensively improving the nursing quality and patient safety level in hospitals.

Ethics Statement

This study was approved by the Hospital Ethics Committee (IIT-2023-573), and all participating patients provided informed consent.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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