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Effectiveness of DMAIC Model in Safe Transport of Emergency Critically Ill Patients

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Abstract

Objective: To evaluate the application effect of the DMAIC model in the safe transport of critically ill patients in the emergency department. Methods: In this study, 50 critically ill patients who underwent in-hospital transport in the emergency department of our hospital from January to December 2024 were selected as the control group, while 50 critically ill patients who underwent in-hospital transport from January to December 2025 were selected as the observation group. The control group received routine transport nursing care, whereas the observation group received the same routine care plus an intervention based on the DMAIC model for transport process optimization. The transport outcomes, transport duration, incidence of abnormal fluctuations in vital signs, and nursing satisfaction were compared between the two groups. Results: The overall incidence of adverse events in the observation group was lower than that in the control group (6% vs. 16%, $P < 0.05$), while the transport success rate was higher (96% vs. 84%, $P < 0.05$). The transport preparation time, handover time, and total transport duration in the observation group were all shorter than those in the control group ($P < 0.05$). The incidence of abnormal fluctuations in vital signs during transport in the observation group was lower than that in the control group (8% vs. 22%, $P < 0.05$). Nursing satisfaction in the observation group was higher than that in the control group (96% vs. 86%, $P < 0.05$). Conclusion: Applying the DMAIC model to systematically optimize the in-hospital transport process for critically ill patients in the emergency department can effectively reduce the time required for each phase of transport, decrease the incidence of adverse events and abnormal vital sign fluctuations during transport, improve transport success rates and nursing service satisfaction, and thereby effectively ensure the safety of in-hospital transport for critically ill patients.

Keywords

In-Hospital Patient Transfer, DMAIC Model, Critically Ill Patients, Safe

Patient Transfer, Six Sigma Management

1. Introduction

In-hospital transfer refers to a systematic and well-planned transfer process within the same healthcare institution, conducted between different medical areas based on a patient's need to undergo necessary examinations or receive necessary treatments [1]. In-hospital transfer of emergency critically ill patients constitutes a high-risk medical phase that integrates monitoring, treatment, and nursing care; it directly determines the success of patient resuscitation as well as the diagnostic and therapeutic outcomes [2]. Critically ill patients present with severe conditions and unstable vital signs; during transit from the emergency department to other relevant departments, they are highly susceptible to various adverse events, which pose serious threats to patient safety and may even compromise their prognosis. Consequently, shortening transfer duration, mitigating transport risks, and ensuring safe and seamless transfer procedures for critically ill patients represent both a key focus and a significant challenge in emergency nursing quality management. The DMAIC model—a cyclical improvement framework within Six Sigma management—consists of five steps: Define, Measure, Analyze, Improve, and Control; it is a widely recognized and important management model [3] [4]. Its core principle is data-driven, employing a closed-loop cycle of "identifying problems → analyzing problems → solving problems" to achieve continuous process optimization. Building upon the DMAIC model, this study applies this framework to the management of in-hospital transfer procedures for emergency critically ill patients. The relevant research findings are reported as follows.

2. Materials and Methods

2.1. General Information

This study employed a non-concurrent before-and-after controlled design and was conducted as a retrospective study. Using a consecutive sampling method, 50 critically ill patients requiring in-hospital transfer who were admitted to the emergency department of Jingzhou First People's Hospital between January and December 2024 were selected as the control group; additionally, 50 critically ill patients of the same type admitted between January and December 2025 were selected as the observation group. In the control group, there were 29 males and 21 females; the age range was 23 - 80 years, with a mean age of (53.42 ± 16.45) years; the modified early warning score (MEWS) was (7.84 ± 1.36) points; the destinations of transfer were the ICU in 23 cases, the radiology department in 12 cases, the interventional catheterization suite in 10 cases, and the operating room in 5 cases. In the observation group, there were 26 males and 24 females; the age range was 25 - 80 years, with a mean age of (52.38 ± 16.74) years; the MEWS score was (5.48 ± 0.68) points; the destinations of transfer were the ICU in 22 cases, the radiology department in 14

cases, the interventional catheterization suite in 8 cases, and the operating room in 6 cases. This study was approved by the hospital's ethics committee.

The inclusion criteria for this study are as follows: 1) The patient meets the criteria for being classified as a critically ill patient and requires emergency in-hospital transport; 2) The transport origin is the emergency department of our hospital; 3) The patient's family members have provided written informed consent.

The exclusion criteria are as follows: 1) Prehospital death or loss of spontaneous circulation at the time of admission; 2) Patients who were abandoned during resuscitation or who ceased cardiopulmonary resuscitation during transport; 3) Patients with incomplete clinical data.

A comparison of baseline characteristics—including gender, age, disease severity, and destination of transfer—between the two patient groups revealed no statistically significant differences ($P > 0.05$).

2.2. Methods

The control group followed the conventional protocol outlined in the expert consensus on in-hospital and inter-hospital transport of critically ill patients [5]. When patient transport was required, the charge nurse notified the relevant departments in accordance with medical orders; prior to transport, routine vital sign assessments were performed, and pre-transport preparatory measures—including oxygen therapy, establishment of intravenous access, and cardiac monitoring—were completed as prescribed; during transport, the patient was accompanied by an emergency department nurse; and upon completion of transport, a verbal handover was conducted with the receiving department [6]. The observation group, building upon the control group protocol, implemented optimized transport process management based on the DMAIC model, with the following specific measures:

1) Definition Phase: Establish a DMAIC patient transfer management team led by the head of the emergency department; develop the "In-Hospital Patient Transfer SOP for Critically Ill Patients in the Emergency Department"; clarify the responsibilities of each team member and the criteria for patient transfer classification; organize specialized training sessions within the department; require personnel to pass the training assessment before assuming their roles; ensure seamless coordination across all workflow stages; and assign specific responsibilities to individual personnel.

2) Measurement Phase: Conduct data recording across three key stages—transfer preparation, during transfer, and patient handover—documenting detailed information regarding adverse events during transfer, thereby providing the foundational data necessary for subsequent analysis and evaluation.

3) Analysis Phase: Organize department personnel to analyze data and adverse events, utilize RAC to identify weak points, and determine the root causes of core issues—such as insufficient pre-transfer assessment preparation time, inadequate inter-departmental communication, or monitoring system failures during transfer—each of which may lead to adverse events.

4) Improvement Phase: Implement corrective measures targeting core issues; prior to patient transfer, develop a tiered transfer assessment form, complete patient evaluation, deploy a "one person, one checklist" protocol, and pre-position emergency equipment while verifying its operational status; during transfer, activate a green channel, coordinate in advance with relevant departments to ensure preparedness, continuously monitor the patient's condition, and assign dedicated nursing staff for accompaniment; during handover, adopt the SBAR standardized protocol—conduct item-by-item verification followed by mutual signing by both parties—to ensure seamless information continuity [7].

5) Control Phase: Establish a continuous improvement mechanism for transfer quality; the team leader shall organize monthly transfer quality debriefings, compile and analyze relevant data for the current month, evaluate the effectiveness of implemented improvements, develop the next round of improvement plans in response to emerging issues, thereby creating a virtuous cycle, and ultimately codify optimized processes into the department's Standard Operating Procedures (SOPs).

2.3. Observation Indicators

1) Transfer outcomes: Compare the incidence of adverse events during transfer (including catheter dislodgement, decreased oxygen saturation, abnormal fluctuations in heart rate/blood pressure, etc.), transfer success rate, and the satisfaction of the receiving department with the quality of handover between the two groups; 2) Transfer duration: Compare the preparation time, handover time, and total transfer duration between the two groups; 3) Abnormal fluctuations in vital signs: Compare the incidence of significant abnormal fluctuations in vital signs (heart rate, blood pressure, oxygen saturation) during transfer in the two groups [8]; 4) Nursing satisfaction: Using a self-developed nursing satisfaction questionnaire from the emergency department of our hospital (maximum score: 100), classify responses as "very satisfied" for scores ≥ 90, "satisfied" for scores 80 - 89, "moderately satisfied" for scores 70 - 79, and "dissatisfied" for scores ≤ 70; calculate the overall satisfaction rate as (number of cases rated as "very satisfied" + number of cases rated as "satisfied")/total number of cases × 100%.

2.4. Statistical Methods

Statistical analysis was performed using SPSS 26.0 software. Measurement data are expressed as mean ± standard deviation ($\overline{x} \pm s$), and inter-group comparisons were conducted using the t-test; enumeration data are expressed as rates (%), and inter-group comparisons were conducted using the χ^2 test. A P-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of Transfer Outcomes between the Two Groups

The overall incidence of adverse events in the observation group was lower than that in the control group (6% vs. 16%, P < 0.05), the transfer success rate was

higher than that in the control group (96% vs. 84%, P < 0.05), and the satisfaction rate of receiving departments with the handover quality was higher than that in the control group (94% vs. 82%, P < 0.05); all these differences were statistically significant. See Table 1.

3.2. Comparison of Transfer Times between the Two Groups

In the observation group, the preparation time for transfer, handover time, and total transfer time were all shorter than those in the control group, and these differences were statistically significant (P < 0.05). See Table 2.

3.3. Comparison of the Incidence of Abnormal Fluctuations in Vital Signs between the Two Groups

In the observation group, the incidence of abnormal fluctuations in vital signs during transport was 8% (4/50), which was lower than that in the control group (22%, 11/50); this difference was statistically significant ($\chi^2 = 3.843$, P = 0.049).

3.4. Comparison of Nursing Satisfaction between the Two Groups

The overall nursing satisfaction rate in the observation group was 96% (48/50), which was higher than that in the control group (86%, 43/50); the difference was statistically significant ($\chi^2 = 3.947$, P = 0.047). See Table 3.

Table 1. Comparison of transfer outcomes between the two groups.

group	Number of cases	Pipeline slippage	Decreased oxygen saturation	Abnormal fluctuations in heart rate and blood pressure	Overall incidence rate (%)
Control group	50	2(4)	3(6)	3(6)	8(16)
observation group	50	1(2)	1(2)	1(2)	3(6)

Note: When comparing the overall incidence of adverse events between the two groups, $\chi^2 = 4.320$, P = 0.038.

Table 2. Comparison of transfer times between the two groups.

group	Preparation time (min)	Handover duration (min)	Total transfer time (min)
Control group (n = 50)	12.36 ± 2.51	8.42 ± 1.68	32.18 ± 3.35
Observation group (n = 50)	7.48 ± 1.62	4.26 ± 1.03	25.63 ± 2.94

Note: Preparation time t = 11.26, P = 0.000; handover time t = 14.58, P = 0.000; total transfer time t = 11.87, P = 0.000.

Table 3. Comparison of nursing satisfaction between the two groups.

group	Number of cases	Very satisfied	satisfied	discontent	Overall Satisfaction Rate (%)
Control group	50	24 (48)	19 (38)	7 (14)	86
observation group	50	33 (66)	15 (30)	2 (4)	96

4. Discussion

In-hospital transport of critically ill patients represents one of the core compo-

nents with the highest risk level in emergency nursing quality management. During this process, patients are removed from their original monitoring and treatment environment and must simultaneously navigate multiple uncertainties, including equipment relocation, personnel handover, and sudden changes in their clinical condition. Should adverse events occur, timely and effective intervention may be difficult to implement, which can directly compromise both the success rate of resuscitation efforts and the patients' long-term prognosis [9]. Therefore, establishing standardized, normalized, and traceable in-hospital transport protocols is pivotal to ensuring the safety of critically ill patient transport.

The results of this study demonstrate that in the observation group, both the overall incidence of adverse events and the incidence of abnormal fluctuations in vital signs were significantly lower than those in the control group, while the transport success rate was significantly higher than that in the control group; these inter-group differences were statistically significant ($P < 0.05$). The mechanistic rationale for these findings is as follows: The DMAIC model first defines the responsibilities of each involved party and the transport classification criteria during the definition phase; in the measurement and analysis phase, it accurately identifies weak links in the transport process; and in the improvement phase, it implements targeted optimizations focusing on pre-transport assessment and preparation, in-transit monitoring and support, and post-transport handover procedures. This approach effectively reduces transport risks and enhances the safety of the transport process. These findings are consistent with previous research outcomes on the application of Six Sigma management methodology to optimize transport processes for critically ill patients.

The results of this study further demonstrate that in the observation group, the preparation time for patient transfer, handover time, and total transfer time were all significantly shorter than those in the control group ($P < 0.05$). Analysis of these findings reveals that the DMAIC model—by establishing a transfer checklist, activating an emergency green channel, and implementing the SBAR standardized handover protocol—effectively reduced redundant steps in pre-transfer preparation phases and interdepartmental communication processes. This approach enabled relevant departments to enter a ready state for patient transfer in advance, thereby significantly shortening the duration of each transfer phase and securing a critical intervention time window for the subsequent treatment of critically ill patients.

The aforementioned results indicate that the DMAIC model can not only enable systematic optimization of emergency department transfer workflows—thereby enhancing safety during transfer procedures, but also effectively improve the patient and family member experience [10]; furthermore, the DMAIC model can foster interdepartmental collaboration between the emergency department and other clinical units, thereby positively contributing to overall healthcare quality and the job satisfaction of cross-departmental staff.

In conclusion, applying the DMAIC model to systematically optimize the in-

hospital transfer process for critically ill emergency patients can effectively reduce the time required in each phase of the transfer process, decrease the incidence of adverse events and abnormal fluctuations in vital signs during transfer, improve transfer success rates and nursing satisfaction, and thereby enhance the safety of in-hospital transfers for critically ill patients. However, this study is a single-center investigation with a limited sample size, involving only patients from our hospital; thus, the generalizability and long-term efficacy of its findings require validation through multi-center randomized controlled trials. In future research, we plan to expand the sample size and conduct multi-center studies to further validate these conclusions.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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