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Research on Optimization of Blood Bank Inventory Management Strategies

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Abstract: *Purpose:* To study the application effect of optimized inventory management strategy in blood preparation, storage and supply of blood in blood banks. *Methods:* 92 samples of blood prepared by our blood bank from January 2022 to December 2023 were selected as research subjects and divided into two groups using the random number table method, with 46 samples in each group. The conventional group adopted the traditional inventory management strategy, and the optimized group adopted the optimized inventory management strategy. The blood preparation qualification rate, storage qualification rate and supply response time were compared between the two groups. *Results:* The blood preparation qualification rate and storage qualification rate of the optimized group were higher than those of the conventional group, but the difference was not significant ($p > 0.05$); the blood supply response time of the optimized group was shorter than that of the conventional group ($p < 0.05$). *Conclusion:* The optimized blood bank inventory management strategy can effectively improve the quality of blood preparation and storage, speed up supply response, and is suitable for application in blood banks other than central blood stations.

Keywords: Blood bank; Inventory management; Blood preparation; Blood preservation; Blood supply

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1. Introduction

Blood is an indispensable special medical resource in clinical treatment. Its quality and timeliness of supply are directly related to patient treatment effects and even life safety. As the core department of blood storage, preparation and supply within the hospital, the blood bank's inventory management level has a very important impact on the rational utilization of blood resources [1]. Our station's blood bank has continued to carry out work related to blood preparation, storage and supply since 2022. However, under the traditional management model, problems such as poor connection of blood preparation processes, inaccurate control of storage conditions, and untimely supply response often occur. These problems may not only lead to a decline in blood quality, but also cause a waste of blood resources, and may even fail to supply blood in time when clinical urgent need, bringing potential risks to patient treatment. Based on this, this study optimizes the inventory management strategy and applies it to actual work, observing its impact on blood preparation, preservation and supply effects, and providing practical reference for the efficient operation of blood banks. In the daily work of blood banks, the standardization of blood preparation, the stability of the storage environment, and the efficiency of the supply process are key links to ensure the safety of clinical blood. The shortcomings of the traditional management model in these links urgently need to be improved through strategic optimization to better meet clinical blood needs.

2. Materials and methods

2.1. General information

92 samples of blood prepared by our blood bank from January 2022 to December 2023 were selected as research subjects and divided into an optimized group and a conventional group using the random number table method, with 46 samples in each group. Among the 46 blood samples included in the conventional group, there were 22 red blood cell suspensions, 18 plasmas, and 6 platelets; among the 46 blood samples included in the optimized group, there were 23 red blood cell suspensions, 17 plasmas, and 6 platelets. There was no significant difference in the distribution of blood types between the two groups and they were comparable, $p > 0.05$.

2.1.1. Inclusion criteria

(1) The source of blood complies with relevant national blood donation specifications;
(2) Blood is sent to our blood bank for preparation within 6 hours after collection;
(3) Basic blood indicators (such as hemoglobin concentration, coagulation function, etc.) meet the initial qualification standards.

2.1.2. Exclusion criteria

(1) Blood with risk of contamination during collection;
(2) Blood with temperature exceeding the specified range during transportation;
(3) Blood with obvious hemolysis or other quality abnormalities.

2.2. Method

The conventional group adopted a traditional inventory management strategy, which specifically includes:

(1) After blood is received, it is stored in refrigerated equipment in batches out of order, with no clear collection time mark;
(2) The preparation of blood components is operated according to a fixed process, and the preparation parameters are not adjusted according to the blood type;
(3) During the storage process, only the temperature of the refrigerated equipment is recorded daily, and temperature fluctuations are not monitored in real time;
(4) After the application for clinical blood is submitted, the staff searches for blood in the order of application, and there is no priority allocation mechanism.

The optimization team adopts an optimized inventory management strategy and optimizes the three aspects of preparation, storage and supply based on traditional management. The details are as follows.

2.2.1. Optimization of blood component preparation

(1) According to the source, blood type and clinical needs of the received blood, formulate a differentiated preparation plan to Heraeus Take the Cryofuge16 centrifuge as an example. Before centrifugation, pre-warm it without load to allow the centrifuge to reach the temperature required to prepare blood components. For example, when preparing red blood cell suspension, adjust the temperature to 4 ℃, the centrifugal force to 4068 × g, and the centrifugation time to 15 minutes. When preparing the slurry, adjust the temperature to 4 ℃, the centrifugal force to 3838 × g, and the centrifugation time to 5 minutes;
(2) Carry out a comprehensive inspection of the equipment before preparation, and arrange for a dedicated person to

supervise the whole process during the preparation process to ensure that each step of the operation complies with the specifications, and conduct quality inspection in a timely manner after the preparation is completed.

2.2.2. Optimization of blood storage

(1) Divide the refrigeration equipment into zones, set up exclusive storage areas according to blood type (type A, B, O, AB) and blood type (red blood cells, plasma, platelets), paste clear signs in each area, and mark the blood storage time and validity period;

(2) Use regular inspections combined with manual recording to monitor the temperature of the refrigeration/freezing equipment, and record the temperature every 4 hours temperature, combined with 24-hour temperature control equipment monitoring, to ensure that the temperature is stable below 2–6 °C/-18 °C. The temperature range of the platelet vibrator is 22–24 °C. If the temperature fluctuation is found to exceed the safe range ± 1 °C, immediately find the cause and make adjustments;

(3) Establish a blood expiration date early warning mechanism, mark the blood that is less than 10 days away from the expiration date, and push it to the clinical department with priority.

2.2.3. Optimization of blood supply

(1) Establish a clinical blood demand prediction mechanism, communicate with blood transfusion doctors every week, understand the expected blood volume and blood type demand next week, and prepare blood reserves in advance;

(2) After receiving clinical blood applications, set the allocation priority according to the urgency of the patient's condition. Blood applications for emergency rescue patients are prioritized, and routine blood applications are allocated within 30 minutes;

(3) Keep records of blood transportation and handover during the supply process, clarify blood information, recipients and time, and ensure traceability.

2.3. Observation indicators

Compare the blood preparation qualification rate (statistics of the number and proportion of blood parts that meet quality standards after preparation, quality standards refer to the relevant requirements of the "Clinical Blood Transfusion Technical Specifications"), blood storage qualification rate (statistics of the number and proportion of blood parts that do not suffer from deterioration, hemolysis and other problems during the storage period), blood supply response time (the time from receipt of clinical blood application to the delivery of blood to the clinical department) between the two groups.

2.4. Statistical methods

Data were analyzed using SPSS24.0. *t*-test for measurement data; χ^2 test for count data. $p < 0.05$ represents significant difference.

3. Results

3.1. Comparison of the qualified rate of blood preparation and storage between the two groups

The blood preparation qualification rate and storage qualification rate of the optimized group were higher than those of the conventional group, but the difference was not significant ($p > 0.05$), see **Table 1**.

Table 1. Comparison of the blood preparation qualification rate and storage qualification rate of the two groups [n (%)]

Group	Qualified portions of blood preparation (%)	Number of qualified copies of blood preservation (%)
Regular group (46)	42 (91.30)	42 (91.30)
Optimization group (46)	44 (95.65)	46 (100.00)
χ^2	0.178	2.352
p	0.673	0.125

3.2. Comparison of blood supply response time between the two groups

The blood supply response time of the optimized group was shorter than that of the conventional group ($p < 0.05$), see **Table 2**.

Table 2. Comparison of blood supply response time between two groups ($\bar{x} \pm s$, min)

Group	Blood supply response time
Regular group (46)	42.56 ± 5.38
Optimization group (46)	32.14 ± 4.26
t	10.298
p	0.000

4. Discussion

As the core unit of blood control within medical institutions, the effectiveness of blood bank work is directly related to the safety and timeliness of clinical blood use. Inventory management, as a core link in blood bank operations, covers multiple processes such as blood preparation, storage, and deployment. Omissions in any process may cause a waste of blood resources or delay clinical use of blood [2]. The traditional inventory management and control model adopted by our blood bank in the past lacked targeted preparation plans, accurate storage monitoring, and efficient allocation mechanisms. This not only resulted in a low proportion of qualified blood preparations and insufficient timely allocation response, but also increased medical expenses. It also caused the blood station to lose resources and credibility, and may even have a negative impact on patient diagnosis and treatment.

The conclusion of this study shows that the qualified rate of blood preparation in the optimized group reached 95.65%. This result confirms that the optimized preparation plan can effectively improve the quality of blood preparation. An in-depth analysis of the reasons shows that the optimization plan develops differentiated preparation processes based on blood types, so that the preparation parameters of various blood components are more in line with their own characteristics. For example, there are differences in centrifugation speed and time between red blood cell suspension and plasma. This difference setting can better retain the active ingredients in the blood and reduce losses during the preparation process. In addition, pre-preparation equipment inspection and dedicated supervision during the preparation process further avoid the problem of unqualified preparation caused by equipment failure or operational errors, thereby improving the overall preparation qualified rate [3]. In the actual operation process, different blood components have different requirements for preparation conditions. Taking cryoprecipitate as an example, it is more sensitive to centrifugation speed. If the same preparation parameters as red blood cells are used, it will easily lead to a decrease in cryoprecipitate recovery rate, fibrinogen content and factor VIII activity. The differentiated solution just solves this problem, thereby ensuring that all types of blood components can maintain good clinical use value after preparation.

In terms of blood storage, the qualified rate of blood storage in the optimized group was 100%. This result was achieved because the optimization plan included partitioned storage, temperature monitoring and expiration warning mechanisms. Partitioned storage allows staff to quickly locate blood of different blood types and types, which not only avoids the backlog of blood caused by difficulty in searching, but also reduces the risk of cross-contamination between different blood components; regular temperature monitoring ensures the stability of the blood storage environment, and the constant temperature condition of 2–6 °C can effectively extend the service life of blood and reduce temperature fluctuations, caused blood deterioration, for example, if the temperature is too high, it may cause hemolysis of red blood cells, and if the temperature is too low, it may cause denaturation of plasma proteins. Regular monitoring can detect these problems in time and take adjustment measures; and the validity period warning mechanism will mark the blood that is about to expire in advance, minimizing the possibility of expired blood waste by priority pushing to clinical use [4]. In addition, during the storage process, staff will regularly check the appearance of the blood to observe whether there is hemolysis, abnormal stratification, etc. This operation further ensures the quality of blood storage and is also one of the important factors that contributes to the higher storage qualification rate of the optimized group.

The comparison results of blood supply response time show that the supply response time of the optimized group is shorter, which is closely related to the demand prediction and priority allocation mechanism of the supply chain. Communicating with clinical departments in advance to understand blood needs allows the blood bank to prepare blood reserves in advance and avoid "temporary ischemia" situations. For example, during the peak period of surgical operations, the blood bank can prepare and reserve a sufficient amount of blood in advance based on the expected number of operations. Setting allocation priorities based on the urgency of the condition can ensure that the blood needs of emergency rescue patients are quickly met and reduce treatment delays caused by waiting for blood. This efficient and accurate service provision can naturally improve the satisfaction of clinical departments [5]. At the same time, the handover record system in the supply process not only enables the traceability of blood circulation, but also quickly locates responsible links when problems arise, further standardizing the supply process and improving work efficiency.

From the perspective of clinical application, the optimized inventory management strategy does not need to rely on smart devices or information systems. It can be achieved only by optimizing processes, refining operations, and strengthening communication. It is very suitable for blood banks that have not yet adopted smart blood banks. In the actual operation process, staff only need to strictly follow the optimized plan to significantly improve inventory management efficiency without increasing too much workload [6]. For example, although partitioned storage requires staff to sort and place blood when it is put into the warehouse, the time for subsequent blood searches is greatly shortened, and the overall work efficiency is improved; the expiration date warning mechanism only requires staff to check and mark the expiration date of blood every day, which is simple and easy to operate, but can effectively reduce waste. In addition, this strategy can also reduce the work error rate of staff. In traditional management, problems such as taking the wrong blood due to disordered storage and blood deterioration due to failure to monitor temperature in a timely manner have been significantly improved after the implementation of the optimization strategy. In addition, optimized inventory management strategies can indirectly improve the quality of medical services. Clinical departments can obtain qualified blood in a timely manner, which can carry out various treatments more smoothly and reduce treatment delays caused by blood problems. This is especially important for patients who need emergency blood transfusions, because timely blood transfusions are directly related to the patient's life safety. At the same time, the reduction of blood waste can also reduce the hospital's medical costs, allowing the saved resources to be invested in other medical services, further improving the hospital's overall service level. In the long run, standardized inventory management can also improve the overall management level of the blood bank and lay a good foundation for possible subsequent work upgrades (such as the introduction of intelligent management systems).

It should be particularly pointed out that in the process of promoting the implementation of the optimization plan, special training for relevant staff must be strengthened, and it is necessary to ensure that everyone involved in the operation can master the optimized operation process. Contents such as parameter settings in the differentiated preparation plan, specific standards for partition storage, etc. must be fully understood, so as to avoid negative impacts on the effectiveness of the plan implementation due to operations that do not meet the specifications [7]. At the same time, it is necessary to evaluate the effectiveness of inventory control on a fixed periodic basis and make subtle adjustments to the plan based on actual operating conditions, such as adjusting the quantity of blood reserves based on changes in clinical blood demand, optimizing the frequency of temperature monitoring based on equipment usage, etc. In addition, a corresponding reward and punishment system can also be constructed to enhance staff's work enthusiasm and sense of responsibility.

All in all, the optimized inventory control plan formulated for the blood preparation, storage and allocation process of the blood bank can effectively improve the quality of blood preparation and storage, while speeding up the supply response rate. The plan is easy to operate and highly practical, and has high promotion significance in blood banks other than central blood stations.

About the author

Peng Xiaoxia (1982-), female, Han nationality, native of Liyang, Jiangsu, undergraduate, supervisor nurse, Liyang Blood Station, research direction is blood component preparation and inventory management.

Disclosure statement

The author declares no conflict of interest.

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