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Statistical Analysis and Countermeasures for Specimen Rejection in the Emergency Department

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Abstract: The rejected specimens from the Emergency Department of the Center of Clinical Laboratory from January 1, 2022 to January 1, 2023 were analyzed to reduce the specimen rejection rates and to improve the quality of inspection. The results showed that there were 1488 samples of rejected specimens and the non-conforming rate was 0.58%. The departments involved were mainly the Emergency Department, the Hematology Department, the Cardiology Department, the Intensive Care Department, and the Brain Surgery Department. Among the reasons for rejection, blood hemolysis accounted for 43.15%, blood coagulation accounted for 26.61%, and the rate of insufficient specimens was 17.14%. Among them, the sample rejection rate for arterial blood gas analysis was the highest, which accounted for 1.74%; followed by specimens for coagulation test, which was 1.18%. These results indicate the main reason for producing rejected specimens is mainly due to not following the standard operating procedure. Specimen rejection can largely be avoided if the standards for specimen collection are strictly followed.

Keywords: Specimen rejection; Statistical analysis; Quality inspection

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1. Introduction

A complete inspection quality control system includes three stages: pre-analysis, analysis, and post-analysis. Accurate and timely inspection reports depend on the quality control of the three stages, especially in the pre-analytical stage. According to some reports, most of the laboratory errors occurred in the pre-analytical stage of the specimens, and only a few occurred during and after the analysis [1-2]. The pre-analysis process includes the instruction from doctors, preparation of specimen by the patient, specimen collection, specimen transportation, specimen reception, and centrifugation, among which the specimen collection method and storage container are the most important. According to statistics, 60% of the reasons for specimen rejection before analysis are related to the collection of specimens [3-5]. Improper collection, storage, and transportation of specimens can cause errors in test results and affect clinical diagnosis and treatment. However, many clinical departments do not pay enough attention to quality control of the pre-analytical stage, resulting in high rates of sample rejection, which not only consumes manpower and material resources, but also delays clinical diagnosis and treatment [6]. Therefore, the quality control of the pre-analytical stage is not only the responsibility of the inspectors, but also the cooperative efforts of clinicians, nurses, and patients [7].

Specimen collection directly affects the test results. If the specimens are not collected properly, it will be difficult to obtain accurate results even if the tests are performed by skilled workers. A pre-analysis quality control system has been established in the laboratory, including the registration of rejected specimen,

in which the information includes the department the specimen is from and reason of rejection. The rejected samples received from January 1, 2022 to January 1, 2023 were analyzed, with the goal of giving timely feedback to the clinic and formulating improvement measures, so as to reduce the rate of sample rejection and ensure the quality before analysis.

2. Materials and methods

2.1. Materials

Source of rejected specimens: Rejected samples submitted by the emergency department of the Clinical Testing Center of the First Affiliated Hospital of Soochow University from January 1, 2022 to January 1, 2023 from all wards and emergency rooms.

2.2. Methods

2.2.1. Sample rejection criteria

(i) Blood hemolysis: The blood had obvious hemolysis that can be observed by the naked eye. (ii) Blood coagulation: The appearance of clots or microscopic platelet aggregation in anticoagulated blood. (iii) Insufficient specimen: The amount of specimen was insufficient or the blood-coagulant ratio was incorrect. (iv) Barcode rejection: Repeated use of the same barcode or the patient had been discharged. (v) Wrong use of blood collection tubes: Different types of blood collection tubes were used together. (vi) Wrong specimen type: The specimen type did not match the testing requirements. (vii) Sent to the wrong department: Other non-emergency specimens were sent to the Emergency Department. (viii) Specimen contamination: the urine was mixed with feces or the feces are not submitted for inspection in time, resulting in a large number of mold growth. (ix) Wrong barcode: The specimens collected from the same patient were labeled with the wrong barcode. (x) No specimen: No specimen was found in the container. (xi) Excess specimen: the amount of anticoagulated blood collected exceeds the blood to anticoagulant ratio.

2.2.2. Handling of unqualified specimens

The nurses in the corresponding ward were informed of the reasons for re-collection of specimens and the corresponding information of the rejected specimens: the barcode of the specimen, the date of receipt, the department for inspection, the name of the patient, the hospital number/bed number, and the test items, the reason for rejection, and recorded in the Laboratory Information System (LIS).

2.3. Statistical analysis

The quantity of rejected specimens and rate of rejection were tabulated using Excel 2003, where rate of rejection = rejected specimens/total specimens × 100%.

3. Results

3.1. Department distribution of rejected samples

From January 1, 2022 to January 1, 2023, the emergency department of the clinical laboratory of our hospital rejected a total of 1488 specimens, and the rate of rejection was 0.58%. There were as many as 32 departments from which the rejected specimens came from. Among them, the departments with high rejection rates were the Emergency Department, Hematology Department, Cardiology Department, Intensive Care Medicine Department, and Brain Surgery Department. The number and proportion of unqualified specimens submitted by each clinical department are shown in **Table 1**.

Table 1. Department distribution of unqualified samples

Department	Quantity (proportion)
Emergency Department	205 (13.78%)
Hematology	201 (13.51%)
Cardiology	175 (11.76%)
Area 69 Critical Care Medicine	124 (8.33%)
Brain Surgery	109 (7.33%)
ICU Center	91 (6.12%)
Emergency Surgery Ward	58 (3.90%)
Department of Neurology, Area 27	56 (3.76%)
Infectious Diseases	56 (3.76%)
General Surgery	55 (3.70%)
Area 51 Gastroenterology	45 (3.02%)
Area 35 Intervention Department	31 (2.08%)
Oncology	27 (1.81%)
20 Respiratory	24 (1.61%)
50 Geriatrics	23 (1.55%)
District 8 Obstetrics	22 (1.48%)
Department of Endocrinology, Area 36	22 (1.48%)
15 Cardiothoracic Surgery	20 (1.34%)
Area 40 Radiation Therapy Department	19 (1.28%)
2 Orthopedics	17 (1.14%)
District 22 Department of Traditional Traditional Chinese Medicine	17 (1.14%)
Cardiovascular Surgery Area 16	15 (1.01%)
Area 25 Burns	13 (0.87%)
9 Gynecology	11 (0.74%)
Department of Endocrinology, Area 23	11 (0.74%)
Area 21 Dermatology	10 (0.67%)
26 Nephrology	9 (0.60%)
Department of Rehabilitation Medicine	8 (0.54%)
District 10 Dentistry	4 (0.27%)
13 Ophthalmology	4 (0.27%)
Area 48	4 (0.27%)
Area 38	2 (0.13%)
Total	1488

3.2. Classification of reasons for specimen rejection

There were as many as 11 reasons for the rejection of specimens, among which the main reasons were blood hemolysis (642 specimens, accounting for 43.15%), blood coagulation (396 specimens, accounting for 26.61%) and insufficient specimen (255 specimens, accounting for 17.14%). The reason of rejection and the quantities and proportions of rejected specimens for each reason is summarized in **Table 2**.

Table 2. Classification of reasons for specimen rejection

Reason of rejection	Quantity (proportion)
Blood hemolysis	642 (43.15%)
Blood coagulation	396 (26.61%)
Insufficient specimen	255 (17.14%)
Barcode rejected	92 (6.18%)
Wrong blood collection tube	54 (3.63%)
Wrong specimen type	15 (1.01%)
Sent to the wrong department	11 (0.74%)
Specimen contamination	11 (0.74%)
Wrong barcode	5 (0.34%)
No specimen	4 (0.27%)
Excess specimens	3 (0.20%)
Total	1488

3.3. Rejection rates of different types of specimens

There are six types of rejected specimens received by the emergency department, among which the rejection rate of arterial blood gas analysis specimens was the highest, which was up to 1.74%, followed by coagulation test specimens, with a rejection rate of 1.18%. The rejection rates of different types of specimens are shown in **Table 3**.

Table 3. Rejection rates of different types of specimens

Specimen type	Number of rejected specimens	Total number of specimens	Rejection rate
Arterial blood gas analysis	95	5457	1.74%
Coagulation test	379	32094	1.18%
Biochemical test	638	91894	0.69%
Stool test	16	4197	0.38%
Routine blood	319	103863	0.31%
Urine test	41	18174	0.23%

4. Discussion

Quality control of the pre-analytical stage is crucial in the analysis of specimens, which requires the cooperation of patients, clinicians, nurses, and test personnel [8,9]. It is better to not perform any tests using substandard samples [10]. There are many reasons for poor specimen quality, including patient preparation, specimen collection, transportation and other links, and it is also related to factors like the patient's physical condition and disease status. For example, patients in the Emergency Department, the Hematology Department, the Cardiology Department, the Intensive Care Department, and the Brain Surgery Department are critically ill and in poor physical condition are critically ill and in poor physical condition, so blood collection is difficult, and poor blood collection may easily lead to hemolysis, coagulation or insufficient blood volume. However, subjective factors cannot be ignored. Through communication with clinical nurses, it was found that most of the rejected samples were produced because the operators did not strictly follow the standard operating procedures. Biochemical test specimens have special requirements for specimen collection and processing, and have high skill requirements for nursing staff [11]. Sample rejection may occur because the staff who collected them is unclear of the blood volume requirements or the coagulation

of blood from different vessels, resulting in insufficient or excess specimens, or that the blood and anti-coagulant are not mixed properly. Human errors like these can be avoided by making adjustments to the system. Personnel training should be strengthened to reduce the rejection rates and improve the overall sampling efficiency.

Mastering the key points of specimen collection and operating in strict accordance with the specimen collection standards are important to avoid sample rejection. The reasons for producing rejected samples are summarized below [7].

(i) The barcode is unclear and cannot be read by the system.
(ii) Improper anticoagulation which causes the specimen to coagulate.
(iii) Specimens not submitted in time.
(iv) Artificial hemolysis.
(v) Improper storage temperature.
(vi) Collected from the infusion tube.
(vii) The specimen is leaking and the container is damaged.
(viii) Visibly contaminated specimens.
(ix) The container is unqualified, affecting the test result.
(x) The amount of specimen is too small.
(xi) Specimens that are discarded upon the doctor's orders

Table 4. Blood collection volume and test tubes used for commonly used test items

Test tube	Test items and blood collection volume
Yellow cap test tube (coagulant tube)	Used for the collection of specimens for biochemical tests like liver function, blood lipids, kidney function, ions, etc.; the blood collection volume is about 3 mL
Purple cap test tube (anticoagulant tube)	Used for routine blood analysis, reticulocytes, blood smear, and other tests; the blood collection volume is about 2 mL, and the tube is gently inverted 4–5 times
Blue cap test tube (anticoagulant tube)	Used for the collection of specimens for blood coagulation tests, D-dimer tests, and other tests. The ratio of blood to anticoagulant is 9:1. Blood is collected to the marked scale, and gently inverted and mixed 4 to 5 times.

5. Precautions for specimen collection and transportation:

(i) For routine blood specimens, the amount of blood should not be too little or too much. After blood collection, it should be mixed thoroughly immediately, and the blood drawing process should be smooth. If the blood vessel of the patient is thin, do not draw blood forcefully but choose a thicker blood vessel for blood collection to prevent blood clotting or hemolysis due to slow bleeding.
(ii) For the collection of coagulation test specimens, the specimen should be strictly in accordance with blood-to-anticoagulant ratio of 9:1. Besides, the volume of blood collected should not be too little or too much.
(iii) When collecting specimens for biochemical tests, the blood should not be collected from the indwelling needle to avoid hemolysis.
(iv) When collecting blood specimens, medical personnel need to ensure that there are no air bubbles in the syringe, and the specimen needs to be sealed immediately to avoid hemolysis [12].
(v) The specimens should be handled with care during the transportation process to avoid hemolysis or spillage.

When specimens are rejected, the specimens need to be re-collected, and sent for inspection again.

This whole process not only delays the process of preparing test reports, but also the diagnosis and treatment of patients, which in turn increases the suffering of patients and cause dissatisfaction among patients. Rejection of samples will also increase the workload of clinical and testing. Therefore, all departments should pay attention to the sampling process to ensure that the specimens collected are up to standard.

Besides, the clinical laboratory should also establish a system to control the rejection rate of specimens, continuously analyze the reasons of rejection, and communicate with the medical staff in a timely manner to effectively reduce the rejection of specimens and ensure the quality of specimen before analysis.

Disclosure statement

The authors declare no conflict of interest.

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