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ORIGINAL ARTICLE

Types and Frequencies of Pre-Analytical Errors in the Clinical Laboratory at the University Hospital of Korea

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SUMMARY

Background: **The results of laboratory tests play a critical role in patient management, so the clinical laboratory is obligated to report accurate results. However, the pre-analytical phase, in which human factors are mainly involved, is clearly a vulnerable part of the laboratory process. This study was conducted to investigate and analyze pre-analytical errors. The author intended to reduce these errors by some measures in order to enhance the credibility of the laboratory.**

Methods: **A retrospective study was conducted to identify the rates and the types and frequencies of pre-analytical errors in the laboratory and analyze them according to the departments of patients, the sections of the laboratory, and the wards of the hospital. The reasons for these errors were persistently identified and analyzed in order to make efforts to reduce the errors. The activities for quality improvement including education and training programs on the phlebotomy teams were also accomplished to reduce these errors.**

Results: **The overall rate of pre-analytical errors was 0.40%. The rate of these errors significantly decreased from 0.44% in 2017 to 0.36% in 2018. In particular, the proportion of improper volume decreased from 46.1% in 2017 to 36.4% in 2018. The most common pre-analytical error was 'improper volume' (41.5%), followed by 'undue clotting' (32.8%). These errors were overwhelmingly more common in inpatients than in outpatients. The rate of these errors was the highest in stat section (1.95%).**

Conclusions: **Clinical laboratory should make efforts to reduce pre-analytical errors in order to report accurate and expeditious results. Reduction of these errors can be achieved through analyzing and correcting the reasons for them and education and training on the phlebotomy teams and, as a result, the credibility of the laboratory may also be enhanced.**

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KEY WORDS

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INTRODUCTION

The processes of medical service for patient care involve risks due to the complexity of the medical environment. In addition, as laboratory testing itself is a highly complex process, it has the potential for risks of errors [1-4]. Nevertheless, strengthening patient safety is being highly emphasized as a key principle for the accreditation of medical institutes in Korea.

As the results of laboratory tests not only play a critical

role in patient management but also have an influence on patient care [2,4-7], the clinical laboratory is obligated to report accurate results.

A laboratory error is any defect that occurs during the entire testing process [1,7-10]. Laboratory testing - a highly complex process, is usually divided into three phases: pre-analytical, analytical, and post-analytical. The clinical laboratory should be accountable for the whole cycle of the testing process, but the pre-analytical phase, where there is a great deal of human involvement, is clearly a vulnerable part of the laboratory process [1,2,5,7]. Several studies have reported that pre-analytical errors accounted for between 61.9% and 84.52% of total laboratory errors [6,7,11]. This is mainly because the processes of the pre-analytical phase are not under direct laboratory control [1,2,12] and are the most complicated part of laboratory testing. Most pre-analytical errors are directly related to the procedure of sample collection, including mistaken patient or sample identification, use of the wrong container, inappropriate blood to additive ratio, insufficient sample volume, undue clotting, spurious hemolysis, sample contamination, labelling error, inappropriate sample management, improper transportation or storage, etc. [6-8,10,11,13]. However, it is difficult to monitor all pre-analytical variables and also extremely difficult for the laboratory to detect all the errors, because many errors do not produce detectable abnormal results [6-8]. Also, from a practical point of view, it is likely not possible to completely eliminate these errors, but these errors can be reduced by some efforts, especially through compliance with the best practice for blood collection, improvement of quality of systematic and total testing process, improved communication with healthcare workers, coordination between the laboratory and the wards, and education for staff in charge of blood sample collection [8,11, 13-18]. So, these errors are known to be preventable to some extent. It is also more cost effective for the hospital or laboratory administrator to prevent and reduce the incidence of these preventable errors [1,2].

Risk management at the medical institutes is critical for patient safety and quality assurance. The first step in risk management is identifying risks by perceiving their existence [19,20]. The key step in reducing pre-analytical errors is to analyze the causes of the errors that have already occurred. A thorough examination of the current blood collection practices is required to analyze the root cause of these errors. The laboratory can prevent these errors and promote quality improvement of laboratory service through monitoring the rejected samples on a regular basis and identifying factors associated with the rejection [14-18]. Quality improvement consists of the consecutive steps of identifying the errors, evaluating, improving, and monitoring related processes. It is also necessary to have specific and corrective actions for the errors in an organized training program to improve the quality of the laboratory [10,21].

The literature review found that not many reported the differences of the types and frequencies of pre-analytical errors according to the sections of the clinical laboratory such as hematology, clinical chemistry, immunology, microbiology, molecular pathology, and so on. However, the types and frequencies of pre-analytical errors were previously reported within the range of specific and limited laboratory services [6,7,14,18,22]. Alternatively, the results of the entire laboratory were reported in the types and frequencies of pre-analytical errors, regardless of the sections [8,10,11,16,23]. Only a few studies referred to the differences of pre-analytical errors according to the sections of the laboratory [17,24-26].

This study aims to identify the rates and the types and frequencies of pre-analytical errors in the hospital laboratory and analyze the reasons for each type of error and also to investigate the differences in the distribution by analyzing the results according to the departments of patients, the sections of the laboratory, and the wards of the hospital. The author intended to reduce pre-analytical errors by carrying out some activities for quality improvement to reduce these errors.

MATERIALS AND METHODS

1. Composition of the phlebotomy teams

The phlebotomy teams consist of ward nurses, medical doctors, and medical laboratory technologists. Ward nurses and medical doctors are in charge of collecting blood samples of the intensive care unit (ICU), neonatal ICU (NICU), pediatric ICU (PICU), and the emergency room (ER) and from other Inpatients' Departments (IPDs) only when the requisition is a stat order. In all other cases, medical laboratory technologists are in charge of collecting blood samples.

2. Laboratory setting

The Department of Laboratory Medicine in Kyungpook National University Chilgok Hospital receives about 1.0 x 10^6 samples and performs about 4.5 x 10^6 tests per year.

The sections in the laboratory include hematology, clinical chemistry, immunology, coagulation, microbiology, transfusion medicine, molecular pathology, urinalysis, stat, and others.

Suitably qualified laboratory staff in charge of the sample reception inspects the sample status as follows: checking the sample status with their own eyes while receiving the samples, checking the sample collection container according to the guidelines. Then the staff decides whether to accept or reject them according to the sample rejection criteria of the laboratory. Pre-analytical errors can also be detected by checking the sample status after sample centrifugation, or by sample status messages on the equipment. The criteria include improper volume, undue clotting, error related to test ordering, improper container, grossly hemolyzed sample, empty container, improper transport, misidentification and others. If the sample is to be rejected according to

these criteria, the laboratory staff in charge of sample reception in the laboratory should keep a record of the reason for sample rejection systematically and the new sample request for laboratory testing in the laboratory information system (LIS) (Ku2.0, Hyundai Information System, Seoul, Korea), which immediately notifies the clinical personnel responsible for the patient's care.

The sectional heads of the laboratory periodically reviewed all the recorded data for rejected samples in the LIS. Data recorded in the LIS were collected monthly, analyzed statistically, and reviewed comprehensively by professors as a quality control activity for samples.

The activities for quality improvement were conducted to reduce the rate of pre-analytical errors from June to September in 2018. They included update of the information in LIS, distribution of the brochure for blood collection procedure, and education and training programs on the phlebotomy teams. The same program was conducted for all three groups and twice for each group. The program contents included the correct method of blood sample collection, reinforcement of the knowledge on standardized blood sample collection procedures, effects of rejected samples on patients, causes of analytical interference, and methods for sample storage and transport.

3. Methods of data collection

A retrospective study was conducted to identify the rates and the types and frequencies of pre-analytical errors in the laboratory from January 2017 to December 2018.

This study was also conducted to analyze these errors according to the departments of patients, the sections of the laboratory, and the wards of the hospital.

The laboratory data were retrieved from the institutional LIS which is connected to hospital information system (HIS) (Ku2.0, Hyundai Information System, Seoul, Korea).

4. Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows (version 23.0 IBM Corporation, Armonk, NY, USA) and Microsoft Excel (Microsoft Corporation, Redmond, WA, USA). Data were analyzed using the Chi-square test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

1. Rate and distribution of pre-analytical errors

In total, 2,070,056 samples were received for laboratory testing over a two-year period and of these, 66% were from the IPD and 34% were from the Outpatients' Department (OPD); of these, 8,230 samples were identified as pre-analytical errors and were rejected from laboratory testing. The overall rate of pre-analytical errors was 0.40%. The rates of pre-analytical errors are shown in Table 1. The rates of these errors significantly decreased from 0.44% in 2017 to 0.36% in 2018 ($p = 0.000$). Of the 8,230 rejected samples, the majority, 6,676 samples (81.1%), were blood samples.

The types and frequencies of pre-analytical errors are shown in Table 1. The most common pre-analytical error was improper volume (41.5%), followed by undue clotting (32.8%). The third common type of error was related to test ordering (12.7%). These three types accounted for nearly 87%, constituting most parts of pre-analytical errors. The frequencies between 2017 and 2018 according to the types of pre-analytical errors showed significant difference ($p = 0.000$).

2. Comparison of pre-analytical errors of IPD and OPD

The difference between IPD and OPD was noticeable: 97.8% of the errors occurred from the IPD and 2.2% were from the OPD ($p = 0.000$). The frequencies between IPD and OPD according to the types of pre-analytical errors showed significant differences in 2017 and 2018 ($p = 0.000$ and $p = 0.000$). The rates between IPD and OPD showed significant difference, 0.61% and 0.02%, respectively, and also showed significant differences in both 2017 and 2018 ($p = 0.000$ and $p = 0.000$). The most common pre-analytical error in the IPD was improper volume (41.8%), followed by undue clotting (33.3%), while in the OPD the most common error was related to test ordering (43.2%), followed by improper volume (29.5%) (Table 2).

3. Rate and distribution of pre-analytical errors according to the sections of the laboratory

The section with the highest rate of pre-analytical errors was the stat section (1.95%). The rates are high in hematology (0.65%), coagulation (0.45%), and microbiology (0.44%) in order (Table 3). Stat and hematology sections accounted for about 50 percent of pre-analytical errors. Improper volume, which accounted for the highest rate of pre-analytical errors, also accounted for the highest rates in hematology, clinical chemistry, immunology, coagulation, and urinalysis sections. The second highest rate of pre-analytical errors was undue clotting, and it showed the highest rate in the stat section. Error related to test ordering was the highest rate in microbiology and molecular pathology sections. In the transfusion medicine section, grossly hemolyzed samples were identified as the most common reason. The frequencies of pre-analytical errors according to the sections showed significant difference ($p = 0.000$).

4. Distribution of pre-analytical errors according to the wards of the hospital

With the exception of the general wards (GW), ER (27.0%) accounted for the highest proportion of pre-analytical errors, followed by NICU (19.6%). Improper volume and undue clotting also accounted for the high percentage in most wards. Undue clotting accounted for the highest percentage in GW (36.5%), ICU (43.1%), and PICU (53.3%).

Table 1. Rate and distribution of pre-analytical errors.

Sample rejection criteria	No. in 2017 (%)	No. in 2018 (%)	Total (%)
Improper volume	2,005 (46.1)	1,412 (36.4)	3,417 (41.5)
Undue clotting	1,352 (31.1)	1,348 (34.7)	2,700 (32.8)
Error related to test ordering	491 (11.3)	556 (14.3)	1,047 (12.7)
Improper container	239 (5.5)	251 (6.5)	490 (6.0)
Grossly hemolyzed sample	56 (1.3)	100 (2.6)	156 (1.9)
Empty container	28 (0.6)	34 (0.9)	62 (0.8)
Improper transport	27 (0.6)	13 (0.3)	40 (0.5)
Misidentification	5 (0.1)	10 (0.3)	15 (0.2)
Others	144 (3.3)	159 (4.1)	303 (3.7)
Total rejected samples	4,347	3,883	8,230 (100.00)
Total samples	989,888	1,080,168	2,070,056
Rate (%)	0.44	0.36	0.40
p-value	0.000		

Table 2. Comparison of pre-analytical errors of IPD and OPD.

Sample rejection criteria	2017		2018		Total	
	IPD	OPD	IPD	OPD	IPD (%)	OPD (%)
Improper volume	1,979	26	1,384	28	3,363 (41.8)	54 (29.5)
Undue clotting	1,343	9	1,339	9	2,682 (33.3)	18 (9.8)
Error related to test ordering	442	49	526	30	968 (12.0)	79 (43.2)
Improper container	236	3	250	1	486 (6.0)	4 (2.2)
Grossly hemolyzed sample	56	0	100	0	156 (1.9)	0 (0.0)
Empty container	26	2	33	1	59 (0.7)	3 (1.6)
Improper transport	27	0	13	0	40 (0.5)	0 (0.0)
Misidentification	5	0	10	0	15 (0.2)	0 (0.0)
Others	130	14	148	11	278 (3.5)	25 (13.7)
Total rejected samples	4,244	103	3,803	80	8,047 (100.00)	183 (100.00)
Proportion (%)	97.6	2.4	97.9	2.1	97.8	2.2
p-value	0.000		0.000		0.000	
Total samples	626,777	363,111	685,508	394,660	1,312,285	757,771
Rate (%)	0.68	0.03	0.55	0.02	0.61	0.02
p-value	0.000		0.000		0.000	

DISCUSSION

1. Rate of pre-analytical errors

The rates of pre-analytical errors decreased significantly from 0.44% in 2017 to 0.36% in 2018. It was probably true that the quality improvement activities to reduce pre-analytical errors in 2018 had an impact on the significant decrease. It was particularly noteworthy that the rate of improper volume decreased from 46.1% to 36.4%. Several studies reported that the rates of these errors were from 0.11% to as high as 7.4% [6,7,10,11, 14-16,20,22-24]. The rates of these errors were reported with a large variation according to the services provided by the laboratory and the healthcare environment of the countries. However, it was difficult to compare the rate of pre-analytical errors with domestic data which were not found.

Table 3. Rate and distribution of pre-analytical errors according to the sections of the laboratory.

Section	H	CC	I	Co	Mi	TM	MP	U	S	Others	Total
Improper volume	1,310	216	442	267	266	25	10	255	93	533	3,417
Undue clotting	1,230	12	16	166	0	12	0	0	1,243	21	2,700
Error related to test ordering	29	82	115	15	276	32	26	10	24	438	1,047
Improper container	33	56	63	21	105	6	11	5	54	136	490
Grossly hemolyzed sample	1	23	5	9	0	37	0	0	12	69	156
Empty container	13	15	8	4	5	0	0	0	13	4	62
Improper transport	0	0	30	0	1	0	0	0	0	9	40
Misidentifi-cation	2	3	0	0	1	4	0	2	0	3	15
Others	27	62	26	7	57	5	2	20	34	63	303
Total rejected samples	2,645	469	705	489	711	121	49	292	1,473	1,276	8,230
Total samples	407,261	470,882	185,185	107,550	160,103	68,109	11,750	140,028	75,434	443,754	2,070,056
Rate (%)	0.65	0.10	0.38	0.45	0.44	0.18	0.42	0.21	1.95	0.29	0.40

Abbreviations: H - Hematology, CC - Clinical chemistry, I - Immunology, Co - Coagulation, Mi - Microbiology, TM - Transfusion medicine, MP - Molecular pathology, U - Urinalysis, S - Stat.

Of the 8,230 rejected samples, the majority, 6,676 samples (81.1%), were blood samples. This supports the fact that most pre-analytical errors are directly related to the blood collection process. The study reported that the majority of rejections (92%) were associated with blood samples [18].

2. Distribution of pre-analytical errors

2.1. Improper volume

This reason possesses the highest rate (41.5%) for pre-analytical errors. The frequencies of this reason were reported from 11.55% to 29.3% [7,8,10,11,20,22,25]. However, the frequency of improper volume was higher in this study.

The studies reported that improper volume was largely due to the difficulty in accessing peripheral veins in IPD and had particularly high frequencies for pediatric, neonate, oncology, and ICU [10,13,25]. In the present study, the frequency of this reason was also particularly high for NICU and ER, 65.4% and 46.5%, respectively. It is judged that because this hospital is specialized for the care of the patients with cancer, it is difficult to access peripheral veins of these patients. Improper volume can affect test results due to inappropriate rate of blood and anticoagulant and also have adverse impacts because all tests prescribed by the physician cannot be completed [1]. To minimize this error, all blood collection tubes should be filled with the correct volume (at least 90% of the stated volume on the tube) [27]. In order to solve this problem, micro-tubes for serum separation and EDTA-treated blood are preferred for blood collection of pediatric, geriatric, oncology, and NICU patients to reduce the sample volume. Poor compliance with written procedure of blood sample collection might also explain this reason. This reason appeared to have been reduced due to the effectiveness of the education and training programs on the phlebotomy teams, one of the quality improvement activities for reducing pre-analytical errors in 2018. Therefore, it was considered necessary to continue this comprehensive approach including education and training for accurate blood collection procedure on the phlebotomy teams.

2.2. Undue clotting

This reason is shown as the second most common cause for sample rejection (32.8%). According to the literature, clotted sample (35%) in coagulation and hematologic tests was the major cause for sample rejection

[25]. In this study, undue clotting was also the major cause in the same sections (44.5%) and possessed the highest rate (84.4%) in stat section for sample rejection. Undue clotting is mainly caused by two reasons, prolonged venipuncture or inappropriate mixing of blood with the anticoagulant after collection [10,13,14]. In this study, undue clotting also seems to occur due to two reasons. One is likely to be due to the patients of IPD in whom it is difficult to access peripheral veins. The other is that improper mixing of blood seems likely to be caused by the carelessness of the blood collection staff. It is necessary to homogenize the blood samples in additive-containing tubes by inverting according to the instructions provided by the tube manufacturer. However, mixing of blood specimens collected with an evacuated tube system appears to be unnecessary. Undue clotting occupied higher percentage in IPD compared with OPD. Blood collections for OPD are performed by well-trained phlebotomy teams and with an evacuated tube system in blood collection centers, so the frequency of this reason appears to be very low in OPD. The frequencies of this reason also turned out to be particularly high for ICU and PICU, 43.1% and 53.3%, respectively. Therefore, it was considered necessary to continue education and training in the medical staff in charge of blood sample collection, especially ward nurses and medical doctors.

2.3. Error related to test ordering

The frequency of this reason is 12.7%. However, this reason possesses the highest rate (43.2%) for sample rejection in OPD. The rate of this reason was revealed to be particularly high for molecular pathology (53.1%) and microbiology (38.8%). This was considered to be due to ordering unfamiliar tests. Therefore, better communication or inter-department cooperation between the laboratory and OPD or the wards would be required to reduce this error.

2.4. Improper container

The frequency of this reason is 6.0%. The frequency of this reason was variously reported from 0.57% to 15.2% [7,10,11,20,25]. This reason accounted for the highest rate of sample rejection in the molecular pathology section (22.4%), followed by the microbiology section (14.8%). This error occurs due to lack of awareness of sample containers. The best preventive strategy for potential problems associated with this error was adequate training of the personnel responsible for the collection of samples and giving them information about the potential problems [13].

2.5. Grossly hemolyzed sample

This reason has a low frequency of 1.9%. The frequency of this reason was variously reported from 1.3% to 53.7% [8,10,20,25]. In the present study, the frequency of this reason was relatively low because the blood sample was rejected only when it was visually severely hemolytic. If it was less hemolytic, the test was conducted and the result was released with the comment as a hemolytic sample. However, this criterion of judgement was pointed out as a problem because it could be subjective depending on the laboratory staff. According to the EFLM (European Federation of Clinical Chemistry and Laboratory Medicine) working group "Pre-analytical Phase" (WG-PRE), the survey about the use of information on hemolysis in the result showed that 37.1% of the participants voted for releasing the value with a comment [28,29]. There are no clear and objective criteria for such treatment, so it is still a matter of discussion. Hemolysis of a sample occurs when blood is forced through a needle, shaking the tube vigorously, and centrifuging the sample before clotting is completed [30-33]. The use of evacuated tube systems resulted in the low rate of sample hemolysis [10]. In this study, most blood collections in OPD were conducted with evacuated tube systems, while they were mainly conducted by syringes in IPD. The frequencies of this reason in IPD and OPD were 1.9% and 0.0%, respectively. In the future, this laboratory, where it is possible to measure hemolysis index automatically by chemical analyzers, will need to find a way to use the hemolysis index appropriately.

2.6. Misidentification

This reason has the lowest frequency of 0.2%. However, this is an error that must be necessarily reduced because it can have a very adverse impact on patient care and be associated with the worst clinical outcome, resulting in unnecessary diagnostic procedures or treatment and causing great confusion to the clinician. This can also very seriously affect the reliability of the laboratory [2]. The rate of misidentification was variously reported from 0.07% to 2.2% [8,10,14,20,25]. This error can be barely identified by the laboratory staff in the process of laboratory test. Moreover, it can be found only by delta check which compared the current test results with the results obtained previously from the same patient before reporting the results. According to the literature, 85% of reported identification errors were detected within the laboratory before result verification [34]. Misidentification is entirely caused by human factors. The best practice for prevention of this error is to identify the patient using open questions about at least two different identifiers. This hospital also emphasizes the importance of patient identification for patient safety, and now it seems to be well established. Mistakes in patient identification of blood drawing can be caused by organizational problems outside the laboratory. Reduction of this error can be achieved by educating for accurate patient identification, and a culture of patient identification should be established for patient safety.

3. Comparison of pre-analytical errors of IPD and OPD

The pre-analytical errors are overwhelmingly more frequent in IPD than OPD [2,8,23,35,36]. In this study, the proportion of IPD in pre-analytical errors was also over-

whelmingly high, amounting to 97.8%. While blood collection of OPD is performed by trained medical laboratory technologists with evacuated tube systems and is also under the direct control of the laboratory, blood collection of IPD is performed by not only medical laboratory technologists but also ward nurses and medical doctors and is conducted outside of the laboratory. One reason for the high rate of IPD is most likely human factors such as the lack of trained phlebotomy teams, the lack of skill for blood collection, and the lack of awareness for blood collection, high turnover or shift of ward nurses and medical doctors, and being too busy [8, 12,35]. Cooperation with medical staff outside the laboratory plays a crucial role to reduce laboratory errors. In addition, adequate sample collection techniques and strict observance with prepared operational procedures are also clearly critical [35]. The most common pre-analytical error in OPD was error related to test ordering. The reason is that OPD is not familiar with order entry compared with IPD, so it is considered that proper communication and more cooperation with OPD are needed.

4. Rate and distribution of pre-analytical errors according to the sections of the laboratory

Improper volume showed the highest frequency in hematology, clinical chemistry, immunology, coagulation, and urinalysis sections. Undue clotting accounted for the highest percentage in the stat section. The types of pre-analytical errors for the microbiology section showed errors related to test ordering, improper volume, and improper container in order. The study reported more common causes of rejection for microbiology specimen were labeling errors, wrong container, unacceptable specimen source, and so on [24]. In this study, grossly hemolyzed samples accounted for the highest percentage in the transfusion medicine section.

5. Distribution of pre-analytical errors according to the wards of the hospital

With the exception of the general wards, ER and NICU showed the highest proportions of pre-analytical errors, 27.0% and 19.6%, respectively. Undue clotting is shown as occupying the highest percentage in ICU (43.1%) and PICU (53.3%), which are high-pressure work environments; their characteristic makes them more error-prone than other departments [20, 25]. Ward nurses and medical doctors are in charge of collecting blood samples of the ICU, NICU, PICU, and the ER. These wards account for 51.9% of pre-analytical errors from IPD.

Pre-analytical errors can delay the reporting of test results. The clinical laboratory plays an important role in helping to save lives by properly and timely reporting of test results, so it has the responsibility for the reduction of these errors. However, because pre-analytical phase includes the step outside the laboratory, cooperation with clinicians and personnel outside the laboratory is very critical [6]. It was considered that ward nurses and medical doctors who had frequent shifts had collected the blood samples in IPD and many of them lacked awareness of the importance of blood sample collection by proper techniques. Medical students in the Department of Laboratory Medicine should be targeted to receive training for blood collection since they later would become medical doctors responsible for the blood collection of IPD [18].

Problems with pre-analytical errors include inappropriate treatment, extra-work from re-collection, additional unnecessary investigation, dissatisfaction with healthcare services, increase of healthcare cost, prolongation of TAT, delayed treatment or medical decision, negative impact on patient outcome, etc. [1-3,8,11,19,20]. Therefore, it is more effective to prevent these errors. This study facilitates establishment of targeted corrective actions and intervention through the activities for quality improvement of samples. The author is committed to implementing programs for continued education in order to reduce possible errors. They include continuous education and training to improve awareness of the importance of blood sample collection by proper techniques and compliance with the correct blood collection procedure, stressing the significance of sample rejection, and preventive methods for medical staff related to phlebotomy.

Lippi et al. reported that there was much better compliance with specimen collection procedures when phlebotomists and medical staff in charge of specimen collection distinctly understood why specimen collections should be done according to the standardized and precise procedure [2]. The study reported that compliance to phlebotomy guidelines is somehow lower in all health care settings that are not under the direct responsibility of laboratory personnel. Therefore, education and training on the phlebotomy teams should be conducted continuously, especially at those health care settings [37].

At present, many clinical laboratories in Korea participate in the Laboratory Medicine Accreditation Program organized by the Laboratory Medicine Foundation, Seoul, Korea. Laboratory Medicine Accreditation Program Standards 2017 has been certified by International Society for Quality in Health Care (ISQua). This accreditation program includes various key indicators including the error rate of patient/sample identification. This laboratory also participates in the accreditation program to maintain the quality of the superior laboratory.

CONCLUSION

This hospital is specialized for the care of the patients with cancer or senile diseases and the care of children with serious and incurable diseases, so it is difficult to access peripheral veins in inpatients. Therefore, in order to reduce pre-analytical errors, it is necessary to analyze and correct the reasons for them and maintain well-

skilled professional phlebotomy teams through continuous education and training programs. In particular, the activities for quality improvement, including the education program on the effects of pre-analytical errors on patients and the causes of analytical interference, are effective in reducing these errors. In addition, this laboratory will continue to participate in the accreditation program to maintain the quality of the superior laboratory. These ways will ultimately improve the credibility of the laboratory and promote patient safety.

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None.

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