

Hemolysis from a nurses' standpoint – survey from four Croatian hospitals

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Abstract

Introduction: Hemolysis can occur during sample collection, handling and transport. It is more frequent when the non-laboratory staff performs sampling. The aim of this study was to assess nurses' knowledge on the causes of hemolysis and consequential impact on the laboratory tests results. Additionally, the differences in knowledge, related to work experience, professional degree and previous education about hemolysis were explored.

Materials and methods: An anonymous survey, containing 11 questions on demographics, causes of hemolysis, its impact on biochemical parameters and nurses' attitude towards additional education in preanalytics, was conducted in four Croatian hospitals. The answers were compared by Chi-squared and Fischer exact test.

Results: In total, 562 survey results were collected. Majority of nurses declared familiarity with the term "hemolysis" (99.6%). There were 77% of correct answers regarding questions about the causes of hemolysis, but only 50% when it comes to questions about interference in biochemical tests. The percentage of correct answers about causes was significantly lower ($P = 0.029$) among more experienced nurses, and higher ($P = 0.027$) in those with higher professional degree, while influence of previous education was not significant. Also, higher percentage of correct answers about interferences was encountered in nurses with longer work experience ($P = 0.039$). More than 70% of nurses declared that additional education about preanalytical factors would be beneficial.

Conclusion: Croatian nurses are familiar with the definition of hemolysis, but a lack of knowledge about causes and influence on laboratory test results is evident. Nurses are eager to improve their knowledge in this field of preanalytical phase.

Key words: hemolysis; nurses; survey; preanalytical phase

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Introduction

The preanalytical phase is recognized as the most vulnerable part in laboratory medicine (1). It is especially challenging to control it in hospitals where it takes place mostly outside the laboratory, involving a variety of medical professionals (physicians, nurses, technicians) (2,3). The largest number of preanalytical errors is related to the hemolyzed samples (approximately 3% of all serum or plasma samples or 40-60% of all unsuitable samples) (3). Results of many laboratory tests are

affected by hemolysis and thus repeated sampling is required, which necessarily leads to additional costs, delay in diagnosis and discomfort for the patient. *In vitro* hemolysis occurs during sample collection or handling e.g. small gauge needles, inappropriate blood collection devices, prolonged venous stasis, fragile veins, vigorous mixing or shaking. It occurs more often when the sample is taken by the non-laboratory staff, with different levels of experience and training in phlebotomy (4).

Phlebotomy in Croatia is performed in hospital wards, primary health care centres and medical laboratories, by medical nurses and laboratory technicians. Although formal education about laboratory process and preanalytical phase is insufficient (5,6) there are numerous recommendations in the literature available to nurses on appropriate blood sampling that reduces the incidence of hemolysis (7-9). Moreover, Croatia is one of the few European countries with official national recommendations on phlebotomy, issued by the Croatian Society for Medical Biochemistry and Laboratory Medicine, Working Group for the Preanalytical Phase (10).

For these reasons, we hypothesized that the knowledge that medical nurses have about the importance of hemolysis in laboratory diagnostics is not sufficient. The aim of this study was to assess the knowledge that nurses in four large Croatian hospitals have about causes of hemolysis and its impact on the laboratory test results. The additional goal was to explore the differences in knowledge, related to work experience, professional degree and previous education in preanalytics.

Materials and methods

Study design

The survey was conducted in four large Croatian hospitals – Clinical Hospital Center Zagreb, Zagreb (CHC Zagreb), Clinical Hospital Center Rijeka, Rijeka (CHC Rijeka), Merkur University Hospital, Zagreb (UH Merkur) and in University Hospital for Infectious Diseases “Dr. Fran Mihaljević”, Zagreb (UH for Infectious Diseases “Dr. Fran Mihaljević”). It was a three week long cross-sectional study conducted in May 2014.

The survey consisted of 11 questions, 1 open type (age in years) and 10 closed type questions (multiple choice questions with only one possible answer). It comprised questions about demographics data, familiarity with the definition and causes of hemolysis, its impact on laboratory test results and attitude about the necessity of additional education in the preanalytics.

The questionnaire was submitted to the heads of laboratory departments and head nurses. After receiving their approval for conducting the survey, the questionnaire form was delivered to the head nurse (printed or *via* e-mail), who distributed copies in printed form to the nurses on wards. Since the participation in the study was anonymous and voluntary no ethical committee approval was requested. All questionnaires, regardless of any missing answers, were accepted and processed. There were no questionnaires with more than one answer.

Statistical analysis

Data were archived in Microsoft Excel 2010 program (Microsoft, Microsoft Excel, Redmond, Washington: Microsoft, 2010. Computer Software). Results were provided as whole numbers and percentages. Chi-square or Fischer exact test was applied for comparisons of percentages between hospitals as well as between groups formed according to participants' work experience, professional degree and previous education on hemolysis. Categories with low frequencies (< 5) were combined to fulfil the requirements for the previously mentioned statistical tests. Statistical analysis was performed using MedCalc 9.4.2.0. statistical software (MedCalc Software, Ostend, Belgium). $P < 0.05$ was defined as the threshold of significance.

Results

In total, 562 survey results were collected. Nurses' age ranged from 19 to 64 years. Distribution of the collected questionnaire results was uneven among hospitals that participated in the questionnaire, with the largest percentage (70%) of results received from CHC Rijeka. Answers from CHC Zagreb comprised 16%, those from UH for Infectious Diseases “Dr. Fran Mihaljević” represented 9% and the remaining 5% were collected in UH Merkur.

Considering the fact that there was a large discrepancy between the number of the survey results collected in CHC Rijeka and in other hospi-

tals, all survey results were initially tested between two groups of results (CHC Rijeka vs. results from three other hospitals combined into one group). Results for questions 1-4, 7, 10 and 11 were tested according to the frequency of obtained answers. The difference between percentage of correct and incorrect answers was tested for questions 5, 6, 8 and 9. If statistically significant difference between results was found, the results for those survey questions were presented separately (Tables 1–3).

Almost all participants were familiar with the term “hemolysis”. The highest percentage of correct answers was observed for questions about the definition of hemolysis (94% CHC Rijeka, 98% other hospitals) and the influence of hemolysis on potassium concentration (83%). Only a small number of nurses (7%) have previously had some kind of edu-

cation about hemolysis and its influence on laboratory test results (Table 1).

Our results pointed to some statistically significant differences in the percentage of correct answers regarding previous work experience (Table 2). Similar results were observed when numbers of correct answers were subdivided into two subgroups according to professional degree. Nurses with higher professional degree had higher percentage of correct answers about possible causes of hemolysis and changes of potassium concentration in hemolyzed sample. Previous continuing education had no influence on the percentage of correct answers for neither question about hemolysis and its influence on the laboratory test results (Table 3).

TABLE 1. Multiple choice survey questions and P-values of tested differences among results obtained from nurses that participated in survey.

Questions	Institution	Answers	Results N (%)	P	Obtained answers (N)
1. Age (in years):	CHC Rijeka*	a) 19-35	80 (34)	< 0.001‡	349
		b) 36-50	116 (49)		
		c) 51-65	40 (17)		
	Other†	a) 19-35	63 (56)		
		b) 36-50	41 (36)		
		c) 51-65	9 (8)		
2. Work experience (in years):	CHC Rijeka*	a) 0-5	30 (8)	< 0.001‡	560
		b) 6-15	97 (25)		
		c) > 15	262 (67)		
	Other†	a) 0-5	32 (19)		
		b) 6-15	46 (27)		
		c) > 15	93 (54)		
3. Professional degree:	CHC Rijeka*	a) high school qualification	252 (65)	0.038‡	554
		b) Bachelor Degree	126 (33)		
		c) Master Degree	8 (2)		
	Other†	a) high school qualification	98 (58)		
		b) Bachelor Degree	60 (36)		
		c) Master Degree	10 (6)		
4. Are you familiar with the term „hemolysis“?	All§	a) yes	551 (99.6)	1.000	553
		b) no	2 (0.4)		

Questions	Institution	Answers	Results N (%)	P	Obtained answers (N)
5. Hemolysis is:	CHC Rijeka*	<u>a) breakdown of blood cells</u>	367 (94)	0.013	559
		b) excessive accumulation of toxic metabolites in blood	7 (2)		
		c) the release of cellular components from leucocytes in the extracellular fluid	5 (1)		
		d) none of the above	11 (3)		
	Otherst	<u>a) breakdown of blood cells</u>	167 (98)		
		b) excessive accumulation of toxic metabolites in blood	0 (0)		
		c) the release of cellular components from leucocytes in the extracellular fluid	1 (1)		
		d) none of the above	1 (1)		
6. Hemolysis may occur:	All§	a) during blood sampling	91 (16)	0.730‡	556
		b) immediately after blood sampling	28 (5)		
		c) in the laboratory procedure	9 (2)		
		<u>d) all answers are correct</u>	428 (77)		
7. How do you react when you get from laboratory information that is necessary to repeat blood sampling due to hemolysis:	CHC Rijeka*	a) immediately repeat blood sampling	315 (82)	0.002 ‡	552
		b) inform your doctor and act according to his instructions	67 (18)		
	Otherst	a) immediately repeat blood sampling	120 (71)		
		b) inform your doctor and act according to his instructions	50 (29)		
8. Hemolysis has an influence on the results of laboratory tests:	All§	a) yes, of all	276 (49)	0.601‡	558
		<u>b) yes, only some</u>	279 (50)		
		c) no influence	3 (1)		
9. In slightly hemolyzed serum concentration of potassium will be:	All§	<u>a) increased</u>	466 (83)	0.940‡	558
		b) decreased	48 (9)		
		c) unchanged	44 (8)		
10. During your continuing education did you have a lecture on the topic of hemolysis, its origin and effect on laboratory tests?	All§	a) yes	38 (7)	0.493‡	558
		b) no	520 (93)		
11. Do you think you should have additional education in the area of influence of preanalytical factors (hemolyses, lipemia, ictericia) on the results of laboratory tests?	CHC Rijeka*	a) yes	288 (74)	0.026 ‡	560
		b) no	102 (26)		
	Otherst	a) yes	141 (83)		
		b) no	29 (17)		

*CHC Rijeka – Clinical Hospital Centre Rijeka

†Others – Clinical Hospital Center Zagreb, Merkur University Hospital, University Hospital for Infectious Diseases “Dr. Fran Mihaljević”

‡Chi-square test

§All - Clinical Hospital Centre Rijeka, Clinical Hospital Center Zagreb, Merkur University Hospital, University Hospital for Infectious Diseases “Dr. Fran Mihaljević”

|| Fisher exact test

Correct answers are underlined.

TABLE 2. Influence of work experience on the percentage of correct answers.

Question	% correct answers		
	Work experience (years)		P
	0 – 15	> 15	
The exact definition of hemolysis*	93† 99‡	96† 99‡	0.249§ 1.000
The causes that lead to hemolysis	83	74	0.029§
Influence of hemolysis on results of laboratory tests	44	54	0.039§
Change of potassium concentration in slightly hemolyzed sample	79	86	0.060§

*Data are presented separately because there is statistically significant difference in correct answers on this question between CHC Rijeka and other hospitals (results presented in Table 1. question 5, P = 0.013)

†Clinical Hospital Centre Rijeka

‡Clinical Hospital Center Zagreb, Merkur University Hospital, University Hospital for Infectious Diseases “Dr. Fran Mihaljević”

§Chi-square test

||Fisher exact test

TABLE 3. Influence of professional degree and previous continuing education on the percentage/ratio of correct answers.

Question	% of correct answers			Ratio of correct answers		
	Professional degree		P	Continuing education		P
	High school qualification	Bachelor and master degree		Yes	No	
Exact definition of hemolysis*	93†	97†	0.157§	0.96†	0.94†	1.000§
	99‡	99‡	1.000§	1.00‡	0.99‡	1.000§
Causes that lead to hemolysis	74	82	0.027 	0.82	0.76	0.539
Influence of hemolysis on results of laboratory tests	50	50	0.981	0.47	0.50	0.888
Change of potassium concentration in slightly hemolyzed sample	80	90	0.004 	0.90	0.83	0.376

*Data are presented separately because there is statistically significant difference in correct answers on this question between CHC Rijeka and other hospitals (results presented in Table 1. question 5, P = 0.013)

†Clinical Hospital Centre Rijeka

‡Clinical Hospital Center Zagreb, Merkur University Hospital, University Hospital for Infectious Diseases “Dr. Fran Mihaljević”

§Fisher exact test

||Chi-square test

Discussion

The results of our study indicate that the vast majority of nurses are familiar with the term “hemolysis” and recognize hemolysis as a breakdown of blood cells. These results provide the first step in dealing with one of the most prevalent preanalyti-

cal errors and one of the biggest challenges to laboratory specialists (11). The choice of subsequent questions (influence of hemolysis on laboratory test results and change of potassium concentration), was aimed to reflect understanding of basic

biochemical principles. Regarding those questions, survey results revealed substantially poorer knowledge. That was, however, partially expected due to lack of formal as well as continuous education in our particular field of interest (5,6). However, inconsistency in relationship between percentage of correct answers in subgroups of participants and previous work experience was quite unexpected. Although there are no literature data to support those findings, this could be explained by a lack of repetition of the acquired knowledge and/or different professional backgrounds among nurses that participated in the study. Survey also revealed that participants do not have an uniform practice regarding consultations with doctors after receiving an information about hemolysed sample. This finding provides additional evidence on harmonization necessity in post-analytical phase (12), because the issue of automatic resampling might gain specific significance in case of critical values, when a reporting delay may cause adverse outcomes (13).

Our results showed that nurses are prepared and willing to improve their awareness of this issue. It should be noted that previous education of the nurses that participated in our study had no impact on the level of knowledge about the subject. In previous studies that investigated the effect of educational intervention on sample collection practice and consequently on the number of hemolysed samples contradictory results can be found. Bolenius *et al.* have found only minor improvements after conducting the education based on the implementation of national and local guidelines on venous blood sample collection in primary health care (14). On the other hand, the same author in another paper concerning similar topic, came to the opposite conclusion that a large-scale educational intervention programme has significantly improved phlebotomists' adherence to venous blood specimen collection practices based on self-reported questionnaire (15). Corkill proved in his work a reduction of rejected samples due to hemolysis as a direct effect of educational toilette posters (16). Even the study conducted among laboratory personnel (Masters of Science in Medical Biochemistry and Specialists in

Medical Biochemistry and Laboratory Medicine) revealed a necessity for intensive education of all personnel included in all phases of laboratory work (17). Some other studies confirmed this finding, not only in Croatia, but also in other developing European countries as well as in Mexico (18).

Although several studies report about the influence of educational interventions on the preanalytical error rates (14-16,19), to the best of our knowledge there is only one study similar to ours. Findings of Yuksel *et al.* point to a low level of knowledge on the causes of hemolysis among nurses that participated in their study and to the importance of continuous education among healthcare workers (20).

The primary goal of continuous education for healthcare personnel that is involved in sample collection outside the laboratory is to raise awareness of the importance of the preanalytical phase and obtaining suitable samples. It is our duty, as laboratory personnel, to transfer knowledge to nurses through any forms of continuing education – lectures, guidelines or educational posters on wards (21). It should be additionally emphasized that education of all personnel included in phlebotomy, not only nurses, represents a key pathway that can remarkably improve quality, as proved in paper by Lima-Oliveira *et al.* (22). Such educational activities might gain significant cost-effectiveness benefits, as evidenced in an interventional study conducted by Ong *et al.* (23). The results of our study can be used for a better understanding of critical points in the knowledge of personnel involved in sample collection outside the laboratory and open the door to a better communication and collaboration between healthcare personnel in the future.

The fact that the study included nurses from only four large hospitals represents one of the limitations. In addition, the majority of answers were collected in one of the enrolled hospitals. Also, information about the ward in which participants work was not collected. One of the limitations of our study is also lack of data on the response rate. Distribution of questionnaires was in the domain of head nurses on wards and thus there were no

specific information on the number of distributed questionnaires as well as the number of nurses who agreed to participate. Moreover, the data on the number of employed nurses in individual institutions were not at disposal, so response rate could not be calculated based on the number of filled out questionnaires included in the study.

In the future, the same questionnaire could be used in evaluating effectiveness and benefits achieved in educational interventions as recommended in the literature (13,14).

Croatian nurses are familiar with the definition of hemolysis, but a lack of knowledge about the causes and influence on laboratory test results is evident. Although the previous education in pre-analytics had no impact on the number of correct

answers regarding questions about hemolysis related interferences on laboratory test results, Croatian nurses are eager to improve their knowledge and are open to further education on the importance of preanalytical errors in the total laboratory testing process.

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Potential conflict of interest

None declared.

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