Research Article

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TBS preanalytical phase working group survey study – preanalytical phase in coagulation laboratories

TBD preanalitik evre çalişma grubu anket çalişmasi – Koagülasyon laboratuvarlarinda preanalitik evre

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Abstract

Objectives: Preanalytical phase quality, which begins with a request for testing and continues with patient preparation, sample collection, transport, processing and storage, is essential for coagulation tests. The Turkish Biochemical Society Preanalytical Phase Working Group created a survey to evaluate the preanalytical phase practices for coagulation laboratories in our country.

Methods: The survey consisted of a total of 26 questions and included almost all steps of the preanalytical phase.

Results: Fifty-four laboratory specialists have participated in the study. The survey results showed that participants have different practices for most stages of the preanalytical phase for coagulation tests.

Conclusion: According to the survey results, a national guideline may help standardisation of the preanalytical phase for coagulation tests in our country and increasing training in this respect would contribute to achieving accurate test results.

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Keywords: coagulation tests; guidelines; patient preparation; patient safety; preanalytical errors; preanalytical phase.

Öz

Amaç: Test istemi ile başlayan, hasta hazırlığı, numune alma, hazırlama ve transportu ve numune depolama ve saklama basamaklarını içeren preanalitik evre kalitesi, koagülasyon testleri için son derece önemlidir. Türk Biyokimya Derneği-Preanalitik Evre Çalışma Grubu, ülkemizde koagülasyon laboratuvarlarında preanalitik evre uygulamalarını değerlendirmek amacıyla bir anket düzenlendi.
Gereç ve Yöntem: Anket toplam 26 sorudan oluşmaktaydı ve preanaliitik evrenin hemen hemen tüm basamaklarını içermekteydi.
Bulgular: Çalışmaya elli dört laboratuvar uzmanı katıldı. Çalışma sonuçlarına göre katılımcıların, koagülasyon testleri için preanalitik evrenin çoğu basamaklarında farklı uygulamalara sahip oldukları görüldü.
Sonuç: Anket sonuçlarına göre, ulusal bir rehber ülkemizde koagülasyon testleri için preanalitik evrenin standardizasyonuna yardımcı olabilir ve bu konuda eğitimlerin arttırılması doğru test sonuçlarının elde edilmesine katkıda bulunacaktır.

Anahtar kelimeler: koagülasyon testleri; kılavuzlar; hasta güvenliği; hasta hazırlığı; preanalitik hatalar; preanalitik evre.

Introduction

Today, a large number of tests are running through different methods in modern hemostasis laboratories. prothrombin time/international normalized ratio (PT/INR), activated partial thromboplastin time (aPTT), fibrinogen, thromboplastin time (TT) and D-dimer are analysed in routine hemostasis laboratories to evaluate congenital or acquired secondary hemostasis disorders [1–3]. PT/INR, aPTT and TT tests are sensitive to various procoagulant factor deficiencies. Besides, PT/INR and aPTT tests are used to monitor the effectiveness of vitamin K antagonists [2, 4, 5], and unfractionated heparin therapy, respectively. Specific diagnostic tests such as coagulation factors, von Willebrand factor (vWF), Protein S, and C, activated protein C resistance (APCR), lupus anticoagulant and platelet function tests are other tests that are performed in coagulation laboratories [3].

In vitro coagulation tests are thought to reflect the coagulation pathway. However, they are more complicated than *in vivo* hemostasis. These tests can be affected by many preanalytical and analytical factors. It should be kept in mind that the use of inappropriate samples may cause significant problems in respect of diagnosis, treatment, and patient follow-up in coagulation disorders [6].

Medical laboratories are responsible for providing accurate test results. As with other laboratory tests, analytical errors are tried to be minimized by using appropriate methods, internal quality control and external quality assessment procedures in coagulation tests. Nevertheless, even if the analytical phase is under control, incorrect test results can be reported due to the preanalytical errors, which may occasionally be out of the laboratories' control [6]. The preanalytical phase starts with physicians' test request and continues with the collection, transport, preparation, and storage of the sample. Preanalytical errors can occur during one of these steps. It is especially challenging for laboratory professionals to control preanalytical errors that occur outside the laboratory boundaries (test request, sample collection and transportation). Studies have shown that preanalytical phase errors, primarily related to blood sample collection and preparation for analysis, are the most frequent among medical laboratory errors [6].

Coagulation laboratories are taken a significant part in the diagnosis, monitoring and treatment of bleeding and thrombophilia disorders. Hence, to achieve high-quality levels for these laboratories, all the steps of the total testing process should be controlled and, standardised. Although there are international guidelines and publications [7–9] as to how to manage and reject unsuitable coagulation test samples, it may not always be possible to comply fully with these guidelines and publications at a national level.

In light of this information, we prepared a preanalytical phase survey based on international guides. The survey aimed to collect coagulation laboratory data, to assess and review the routine practices and evaluate the needs for preanalytical phase standardisation in our country. The information from this survey will be the starting point for the development of national guideline and recommendations for standardisation of the preanalytical phase for coagulation laboratories at the national level.

Material and methods

The Turkish Biochemical Society (TBS) Preanalytical Phase Working Group identified any possible coagulation laboratory preanalytical phase problems according to the literature reviewed, and the survey

has been prepared based on current international guidelines [7, 8]. The questionnaire consisted of 26 questions (supplemental Table 1). The first part of the survey contained questions about the institution, coagulation tests performed, and the number of coagulation tests runs per year. The second part included questions about patient status, blood sample collection, transport of samples, sample processing, interferences, and storage of samples steps. The survey questions were uploaded to the electronic online survey tool (SurveyMonkey®, San Mateo, USA*). After approval by TBS Executive Board, the online survey web address was announced to TBS members by email and asked to complete the survey between December 2017 and February 2018. For objective results, the participants were asked to complete the survey considering routine practices in their laboratories and not ideal conditions. Survey Monkey data was conveyed in Microsoft Excel format (Microsoft Corporation, 2010) for analysis. Statistics were reported as numbers and percentages.

Results and discussion

Fifty-four medical laboratory specialists have participated in the questionnaire. The roles of their laboratories, coagulation tests analysed and, the total numbers of coagulation tests per year are shown in Table 1.

Table 1: Positions of the participating laboratories, coagulation tests performed and, the number of coagulation tests performed per year.

Position of the laboratory	n (%)
Ministry of Health hospital laboratory	20/54 (37.04%)
Training and research hospital laboratory	19/54 (35.19%)
University hospital laboratory	8/54 (14.8%)
Private laboratory/ private hospital laboratory	6/54 (11.11%)
Public health laboratory	1/54 (1.85%)
Coagulation tests performed in the laboratory	
Only PT/INR	1/54 (1.8%)
Routine coagulation assays (PT/INR and/or APTT and/or fibrinogen and/or thrombin time)	53/54 (98.1%)
Specific coagulation tests	8/54 (14.8%)
Thrombocyte function tests	5/54 (9.25%)
Number of coagulation tests in total performed per year	
<5000 tests/year	4/54 (7.4%)
5000–10,000 tests/year	9/54 (16.7%)
10,000–50,000 tests/year	14/54 (25.9%)
50,000–100,000 tests/year	6/54 (11.1%)
100,000–200,000 tests/ year	9/54 (16.7%)
>200,000 tests/year	12/54 (22.2%)

Results are given in the form of the ratio of answers to the total number of answers (n) and in percentage (%).

Patient information

Anticoagulant drugs (warfarin, heparin, low molecular heparin, direct oral anticoagulants, etc.) could affect the coagulation test results. For example, heparin may cause false-positive lupus anticoagulant test result and low factor levels, and direct oral anticoagulants may result in low protein C and S levels [10–15]. Moreover, after a thrombotic attack, some specific coagulation tests (such as activities or concentrations of natural inhibitors and coagulation factors) may decrease due to consumption or entrapment of these factors in the thrombus [16, 17]. Therefore, laboratory specialists should get the patient information before the evaluation of the coagulation test results, especially for the prevention of patient information errors. Nevertheless, the survey results show that most laboratory specialists could not obtain clinical information including the diagnosis of the patients (61.22%) and also this information was not transmitted to them by the clinicians (70.83%) (Table 2). Information forms containing the patients' demographical and clinical data can be prepared by laboratory specialists and ensuring that clinicians complete these forms correctly would be beneficial.

Blood sample collection

Patient status

For coagulation tests, some additional information (e.g., fasting for 8–12 h, non-smoking in this period, avoidance of physiological stress, blood collection after resting of 10–15 min etc.) is needed in addition to the standard blood collection requirements. Although the CLSI H21-A5 standard contains detailed information on the sampling, transportation, preparation and storage conditions for coagulation and molecular hemostasis tests, it provides no information about fasting and the time of day when the sample should be taken [7]. There are a limited number of studies in this respect in the literature [18, 19]. According to Lippi et al., AT III activity increases at the first and fourth hours after a meal, while aPTT decreases at the second hour after a meal as distinct from basal level [19]. Nonetheless, the European Federation of Clinical Chemistry and Laboratory Medicine Preanalytical Phase Working Group recommends taking blood samples between 7 am and 9 am. and standardising the fasting periods according to 12 h [20]. According to the survey results, 87.5% of laboratories admitted accepting samples at any time of the day without considering fasting status (Table 2).

Table 2: Survey results related to some critical preanalytical stages.

Questions	n (%)
Q4. Are you able to obtain clinical information (diagnosis, anticoagulant medicines used, etc.) about the patients?	
Yes	33/54 (61,22%)
No	21/54 (38.88%)
Q6. Which patient status (fasting or non-fasting) are you accept for coagulation tests in your institution?	
Accept samples taken at any time of day	47/54 (87.5%)
Accept the sample drawn after fasting for at least 8 h at 7–9 am in the morning	7/54 (12.5%)
Q7. Which type of citrate tubes do you use for coagulation tests?	
Sodium citrate (Na-citrate) 3.2% (105 or 109 mmol/L)	45/54 (83.3%)
Sodium citrate (Na-citrate) 3.8% (129 mmol/L)	3/54 (6.25%)
Both 3.2% and 3.8% tubes are used	6/54 (10.42%)
Q9. Do you correct citrate concentrations according to the hematocrit levels of the patient?	
Yes	5/54 (10%)
No	49/54 (90%)
Q11. What is the order of draw for coagulation tube when drawing blood from a patient request biochemistry, CBC, sedimentation and coagulation tests?	
First order	33/54 (61.1%)
Second order	9/54 (18.4%)
Third order	6/54 (10.2%)
No order of draw	6/54 (10.2%)
Q12. What is the mixing number of coagulation tubes in your laboratory?	
1–3 times	19/54 (35.9%)
3–6 times	35/54 (64.1%)
Q16. What is the accepted tube fill ratio in your laboratory?	
±10% of the nominal fill line	35/54 (64%)
≤80%	18/54 (34%)
Q19. How do you obtain platelet free plasma (PFP) for coagulation tests?	
With a single step centrifuge procedure	42/54 (78%)
With a double step centrifugation procedure	12/54 (22%)
Q23. What would be your approach if the plasma sample is hemolysed?	
Analyse sample and report the results	2.3/54 (4.3%)
Provide results with the comment	19.6/54 (36.2%)
Provide a report for the results without any explanation in case of urgent tests	2.3/54 (4.3%)
Reject the sample and, ask for a new one	29.8/54 (55.3%)

Tourniquet time

During the blood collection period, the use of a tourniquet is the most common method to increase venous visibility and, select the most suitable vein. A tourniquet should be applied on a point that is 7–10 cm above the blood collection site and, it should remain applied for less than 1 min [21]. A longer tourniquet time can cause variations in the coagulation test results due to venous stasis due to hemoconcentration, and the infiltration of the tissue fluid by blood [22, 23]. Despite the fact that this may be an important factor in causing errors, 10.64% of the laboratories indicated that the tourniquet time is not crucial in coagulation tests. In comparison, 65.96% of the laboratories suvrveyed emphasized that <1 min and a further 23.4% stated that <30 s is essential for reliable coagulation test results.

Citrate as anticoagulant

Sodium citrate is recommended as an anticoagulant for coagulation test samples and usually, a 9:1 blood to sodium citrate ratio is used with a buffer range between 3.2% (105–109 mM) and 3.8% (129 mM). In the 3.8% sodium citrate tube, the excess sodium citrate can potentially bind more calcium ions present, for example, as

added back into the clot-based assay and result in longer PT and aPTT times [7]. According to studies, if coagulation tests reference ranges are determined for sample tubes with lower citrate concentrations, increased PT and aPTT and, decreased fibrinogen results may be obtained from higher citrate concentrations tubes (129 mM, 3.8%) [24, 25]. This difference would be more significant in higher PT/INR results obtained from patients on warfarin therapy [7]. The CLSI H21-A5 standard [7] recommends the use of sample tubes with lower citrate concentrations (105–109 mM, 3.2%). According to the survey results, most of the laboratories (83.3%) are used 3.2% citrated tubes. However, it is interesting that 6.25% of the laboratories use 3.2% and 10.42% of the laboratories use both 3.2% and 3.8% citrate tubes (Table 2). Since there may be reference range variances between these two concentrations, laboratories should standardise their tubes and determine the reference intervals accordingly.

Hematocrit correction

A high hematocrit level (>55%) would change the anticoagulant/plasma ratio. This change can adversely affect coagulation test results [26]. CLSI H21-A5 recommends correction of citrate concentration for >55% hematocrit levels [7]. However, according to the survey results, 90% of the participating laboratories did not make such a correction (Table 2). The guide recommends the use of the formula "citrate concentration = [1.85 × 103] X [100 − hematocrit] X [blood volume]" for the hematocrit correction [7]. As a simpler practice, a protocol is provided indicating that before drawing the blood, 0.1 mL citrate is drawn from 5 mL tubes containing citrate of 3.2% [7].

Order of draw

The CLSI GP41-A6 and the TBS national venous blood collection guideline recommend the specific blood order of draw and drawing blood in the citrated tube in the first-order [21, 27]. Contamination of the coagulation test samples with other anticoagulants such as Ethylenediaminetetraacetic acid (EDTA) and lithium heparin and thrombin clot activators may result in serious problems for test results [7]. We asked the blood order of draw for the coagulation tube when biochemistry, whole blood count, sedimentation and coagulation tests are requested in the survey. However, the answers of the participants were quite impressive. Laboratory compliance with guidelines recommendation was 61.11%. In contrast, 10.2% of the laboratories indicated that there is no such order of draw, while 18.37% said they draw the sample in the second-order and, 10.2% said they draw the sample in the third place for coagulation tests (Table 2).

Sample tubes filling

The sample/anticoagulant ratios and filling the samples up to the volume as indicated on the sample tubes are critical for coagulation tests. According to CLSI H21-A5 standard, blood collection of ±10% of the nominal fill line would be sufficient for coagulation tests [7]. Answers to the question in the survey in this respect prove that 64% of laboratories comply with the respective guides' recommendations concerning the tube nominal fill ratio. However, 34% of the laboratories accept a fill ratio of ≤80% and, 2% of the laboratories stated that they run coagulation tests without considering the tube filling ratio (Table 2). It should be kept in mind that an underfill of tubes might cause dilution of the sample and longer coagulation time due to the capacity of citrate to bind excessive calcium. In respect of the determination of the tube fill ratios, manufacturer recommendations and scientific articles are as important as the respective national and international guides. According to survey results, laboratory specialists are taken into consideration both national and international guidelines and manufacturers' recommendations about the coagulation tube filling ratios. One of the remarkable findings of the survey was the high use of individual experiences for tube filling ratios (27.91%).

The participant laboratories have different practices for under or overfilling sample tubes. 76.6% of the laboratories rejected these samples according to their sample acceptance and rejection criteria. In contrast, 4.26% of laboratories stated that they ran these samples and reported the results and 10.64% indicated that they reported the results with comments and 8.51% said that they report the results when they are within the reference ranges.

Mixing of sample tubes

It is critical to mix the tube gently by inversion 3–5 times to provide adequate mixing of the anticoagulant and blood and prevent clot formation after blood sampling. The most important preanalytical error source in both hematology and coagulation laboratories are clotted samples. Besides, rigorous shaking would cause both *in vitro* hemolysis and artificial coagulation factor activation [28, 29]. As reported by two independent studies, if the tubes are adequately

filled, and the tests analysed quickly, during the blood collection procedure the mixing of blood and anticoagulant may be adequate to enable reliable results for routine coagulation tests [28, 29]. According to our study, 64.1% of the participants mix the samples 3–6 times after blood sampling, while 35.9% of them mixed just 1–3 times (Table 2). In this respect, it would be appropriate for the laboratories to act following their conditions and the experiences. We believe that clotted sample rejection rates should be determined as indicators. Following these ratios at specified intervals and applying corrective and preventive action according to the predetermined target value will be a useful guide for laboratories.

Transport of samples

Transport time and temperature

According to international guidelines [7, 9], whole blood coagulation samples should be transferred to the laboratory as soon as possible (ideally within 1 h) at ambient temperature (15–22 °C). Transfer of these samples in the cold environment is not recommended due to the activation of F VII, loss of the von Willebrand factor and, thrombocytes degradation. After sample collection, aPTT should be run within 4 h, and the PT/INR within 24 h [30, 31]. However, if the aPTT test is used for heparin therapy monitoring, the sample should be centrifuged within 1 h because of the neutralization of heparin by platelet factor 4 [32, 33]. Delay in transportation would result in extended coagulation time and loss of *in vitro* factor activities [34].

Both excessively cold and hot transport conditions should be avoided for coagulation tests. Transfer time is critically important, especially for unstable coagulation factors (F V, F VIII). Our survey results showed that 57.14% of the laboratories transport their coagulation test samples at the temperature and time suggested by the guides. Besides, 2% of the laboratories stated that they transport the samples at 4–8 °C within 1 h, while 8.16% of the laboratories transport the samples at 15–22 °C within >2 h.

Transport time and temperature is important for specific coagulation tests, especially labile factors (FV and FVIII). According to the survey, the sample transport temperature and duration of the laboratories running the specific coagulation test are varied. 26.92% of laboratories transport samples at 15–22 °C within 1 h, 19.23% of laboratories transport samples at 4–8 °C within 1 h; 7.70% of laboratories transport samples at 4–8 °C within >2 h and 7.69% of laboratories transport samples at 15–22 °C within >2 h 11.54% of laboratories use the pneumatic transportation system, and 11.54% of laboratories said that they draw the samples for specific coagulation tests in the laboratory.

A pneumatic system can be used for sample transport in hospitals. According to the survey result, 32.65% of the laboratories use a pneumatic system to transport the coagulation samples. Due to vibration during the transportation of samples with a pneumatic system, foaming, which causes platelet activation and protein denaturation may occur [7].

Sample processing

Centrifugation

Centrifugation is the most critical step in the process of obtaining platelet free plasma (PFP) for coagulation tests. Plasma is called as PFP when the number of platelets is $<10 \times 109$/L (or 10 000/μL). In medical laboratories, swing-bucket and fixed-angle rotors are the most preferred centrifuge types for the sample preparation [34, 35]. However, swinging-bucket rotors are the most suitable in order to minimize the contamination of the plasma with platelets and other blood cells [7]. The ideal centrifugation conditions (at ambient temperature (15–22 °C), $1500 \times g$ and 10–15 min) to obtain PFP are stated in the respective guidelines; however, the centrifugal force and time can be determined according to the laboratory conditions [7]. A shorter centrifugation time may be used for routine coagulation tests. However, these samples must not be used for additional specific coagulation tests. Higher ($>1500 \times g$) centrifugal force is not preferred since it may cause platelet activation and hemolysis [36]. A double step centrifugation protocol may also be used to obtain PFP. According to survey results, 78% of the laboratories prepare their plasma samples with a single step centrifugation protocol whereas 22% use double step centrifugation protocol (Table 2).

In centrifuges, repulsion generated during the rotational motion acts radially from the center to the particles in the sample. It is known as the relative centrifugal force (RCF) or Gravity (g). RCF is expressed as multiples of gravitational acceleration ($\times g$). RPM (number of rounds per minute) is the number of rotations per minute in the centrifuge and the speed indicator of the centrifuge. RCF and RPM are often used interchangeably and mixed. Since different centrifuges have a different radius, even if

they have the same RPM, the RCF values will be different. Therefore, RCF provides the same acceleration and centrifugal force standardisation in different centrifuges [35]. Interestingly, although laboratories were asked to provide centrifugal force as RCF, 42% of them indicated it as RPM. It is essential using refrigerated-centrifuges for coagulation tests, but it can always be challenging to achieve. Non-refrigerated centrifuges can be used without being allowed to overheat [7]. Answers to the questions in the survey concerning the centrifugal force, temperature and time were significantly varied between laboratories, which causes one to think that there are essential problems in particular with the standardization of the centrifugation procedure used in the preparation of samples. We are considering organizing periodic training for users according to national and international guidelines in order to help in the standardisation of centrifugation procedure.

Interferences

Hemolysis

Hemolysis occurs when the erythrocytes are lysed and, the content of the erythrocyte is released into the plasma. Inappropriate venous blood collection and sample preparation result *in vitro* hemolysis [7]. Some disease conditions, such as autoimmune or hemolytic anaemia, serious infections, intravascular disseminated coagulation, transfusion reactions, hereditary and aquired or iatrogenic conditions, may cause *in vivo* blood cell lysis as well [36, 37]. Hemolysis can cause both analytical and biological interference in coagulation tests [37, 38]. Free hemoglobin causes high absorbance readings in optical methods, while cytoplasmic and plasma membrane molecules such as tissue factors, proteases, phospholipids and ADP can cause erroneous results by inducing blood coagulation, and pseudo-activation in platelets [37, 38]. Grossly hemolysed samples should be rejected. However, if the patient has *in vivo* hemolysis and the test must be pursued, the mechanical endpoint analysis method is recommended, and the potential effect of activation should also be noted [36]. According to survey results the participant laboratories have different practices for hemolysed samples. 55.3% of the laboratories rejected these samples. In contrast, 4.3% stated that they run these samples and report the results, 36.2% indicated that they report the results with comment and 4.3% said that they report the results when these are within reference ranges (Table 2).

Lipemia

Hypertriglyceridemia can cause interference in the coagulation tests. This interference can occur as light scattering, volume displacement, as well as direct interaction of lipid particles with hemostasis reactions [37, 38]. Regarding lipemic plasma samples, out of the laboratories participating in the survey; 47.06% of them reject the sample; 50% of them report the results with a comment and 2.94% of them report the results without any explanation if the tests are urgent.

Icterus

Interference from icterus causes spectral interference [37, 38]. In modern coagulometers, special wavelengths are used, and icterus does not cause interference up to 20 mg/dL [37, 38]. In our study, the participant laboratories have different practices for icteric samples. 34.3% of the laboratories reject these samples. In contrast, 8.57% of laboratories stated that they run these samples and report the results and 54.29% indicated that they report the results with a comment and 2.86% said they provide a report for the results without any explanation thereon if the tests are urgent.

Storage of samples

The samples must be frozen for routine and specific coagulation tests if they are not to be analysed within 4 h. Many coagulation tests are stable at -20 °C for 2 weeks in a no-frost deep freezer. When samples are stored at <–70 °C, coagulation tests remain stable for 6–18 months [7]. The participant laboratories had different sample storage practices. 35.29% of the laboratories store the plasmas after centrifugation at –20 °C and 5.88% said that they store them at <–70 °C until the day of analysis for long-term storage. According to the survey results, 41.18% of the laboratories store plasma samples at 2–8 °C and 11.76% store at 15–25 °C. However, 2.94% of laboratories store samples at 15–25 °C and 2.94% at 2–8 °C as whole blood.

Frozen specimens should be thawed at 37 °C for 5–10 min, carefully mixed and analysed immediately [7, 9, 39]. The approach of the laboratories to thawing frozen samples were also different; %39.58 were thawing samples in the refrigerator; 43.75% at ambient temperature and 16.67% at 37 °C for 5–10 min.

Conclusion

The preanalytical phase is the most prone to error during the total testing process. It is critically important to continuously monitor preanalytical errors and improve the quality of patient safety. A variety of tools can be used to detect and correct these errors. These include; training of staff about error types and sources, accurate assessment of sample quality (e.g., sample volume, blood/anticoagulant ratio, identification of possible interferences and contaminants), and recording and monitoring of unexpected results that are inconsistent with clinical information. Standardization of the preanalytical phase contributes to the control and prevention of errors in coagulation laboratories, as in all other laboratory tests [40]. Due to large laboratory networks, different blood collection centers, and the use of various analytical systems, standardized and easy-to-understand procedures, protocols, and consequently guides are required for patient preparation, sample collection, transport, preparation and storage. Our survey showed substantial variability in preanalytical practice and policies among coagulation laboratories. With regard to this we think we need national guidelines and more frequent training. This phase is more prone to errors because of varied professional involvement from different disciplines (clinicians, nurses, phlebotomists, laboratory technicians, supportive and auxiliary personnel) [41]. Besides, increasing test requests and the number of samples may cause weakness and lack of attention in compliance with the procedures for all personnel involved in the process. Therefore, training may be planned and given by laboratory specialists minimum once a year so as to increase both the level of knowledge and quality of coagulation test results for disciplines involved in the preanalytical phase.

Study limitations

Although the survey had already been published for 2 months, and the members of TBS had been reminded via e-mail weekly, participation was less than expected. However, although we didn't receive completed questionnaires from all laboratories performing coagulation assays, we believe that the distribution of respondent institutions (as in the role of the institution, coagulation tests performed in the laboratory and number of coagulation tests in total performed per year) reflect almost all the country.

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Footnote:* Visit www.surveymonkey.com for more information.

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