

Are laboratories following published recommendations for lupus anticoagulant testing? An international evaluation of practices

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Summary

Laboratory tests for lupus anticoagulants (LA) are commonly performed to evaluate thrombosis or suspected phospholipid antibody syndromes. To determine current LA testing practices, and if they conform to published recommendations, two questionnaires were distributed to clinical laboratory members of the North American Specialized Coagulation Laboratory Association (NASCOLA) and the ECAT Foundation (ECAT). The first and second questionnaires were completed by 113 and 96 laboratories, respectively. Commonly performed LA tests included the dilute Russell's viper venom time, LA sensitive activated partial thromboplastin time and hexagonal phospholipid test. Although some laboratories did single LA tests if requested, the majority complied with published recommendations: to use platelet poor plasma for LA tests; to use two or more screening tests, representing different assay principles, and one assay having a low phospholipid concentration to exclude LA; to confirm LA phospholipid dependency by the method giving an abnormal LA screen; to document the inhibitor activity on pooled normal plasma; and not to use phospholipid antibodies to confirm LA. A minority (<35%) followed the recommendations to exclude factor deficiencies and factor inhibitors as the cause of an abnormal LA test. After participating, 32% of laboratories had changed practices and 20% indicated that they would be changing practices. While most laboratories generally follow published guidelines for LA testing, few follow recommendations to evaluate for other coagulation abnormalities. Questionnaires may be helpful quality initiatives to improve compliance with laboratory testing guidelines and recommendations.

Keywords: lupus anticoagulant, phospholipid antibodies, coagulation inhibitors, ISTH guidelines

Introduction

Lupus anticoagulants (LA) are heterogeneous IgG or IgM autoantibodies which inhibit phospholipid-dependent assays of blood coagulation by binding to plasma phospholipid-binding proteins such as beta 2-glycoprotein I or prothrombin (1-9). Laboratory tests for LA are commonly performed by clinical laboratories to evaluate individuals with a prolonged activated partial thromboplastin time (APTT), vascular thromboses, recurrent fetal loss and/or suspected antiphospholipid syndrome, or to assess thrombotic risks in systemic lupus erythematosus (3, 10-15).

Numerous laboratory methods are available for LA testing and guidelines on LA testing and diagnosis have been in existence for more than 20 years (4, 5, 10, 15-19). Some of the more recent detailed recommendations (summarized in Table 1) were published by the International Society on Thrombosis and Haemostasis (ISTH) Subcommittee on Lupus Anticoagulant/Phospholipid-dependent Antibodies in 1995 and the Haemostasis and Thrombosis Task Force of the British Committee for Standards in Haematology (BCSH) in 2000 (5, 17). In 2002, the USA College of American Pathologists (CAP) Consensus Conference recommended that laboratories follow ISTH recommendations on LA testing, and suggested that they preferentially use commercial, "integrated test

systems” for the diagnosis of LA (5, 15). Uncertainties about current LA testing practices, and whether common practices comply with published recommendations, prompted us to query the members of two proficiency testing programs (NASCOLA [North American Specialized Coagulation Laboratory Association] and ECAT [ECAT Foundation]) using several questionnaires to evaluate international practices. We documented some commonalities in practice patterns among laboratories and discovered that many laboratories comply with some, but not all, published LA testing recommendations.

Materials and Methods

The study was conducted in accordance with institutional ethics review board guidelines and the ethical principles for medical research involving human subjects as set out in the Declaration of Helsinki.

Two patterns of practice questionnaires were distributed to the member laboratories of the international organizations, NASCOLA and ECAT, which offer external quality assessment surveys in common, including proficiency testing for LA. Questionnaire 1 (Q1) was distributed in 2005 and contained 59 detailed questions on how LA screening and confirmatory assays were performed and interpreted by individual laboratories, and criteria used for mixing study interpretation (e.g. Rosner Index (20, 21) and other options outlined in the BCSH and ISTH guidelines (5, 17)). Q1 also included a request to provide the LA testing algorithm used by the site. Questionnaire 2 (Q2), distributed in 2007, contained 26 questions to gather more information on the assays performed and it included direct questions about compliance with specific recommendations outlined in published international guidelines, as summarized in Table 1 (5, 17). The responses (submitted by paper for Q1 and on-line for Q2) were entered into a database. After double-checking database entries for accuracy and duplicate entries, data were analyzed blinded to participant identities.

Compliance to ISTH and BCSH (5, 17) recommendations were determined by analysis of LA test algorithms for Q1 and the responses to direct questions for Q2. Data were also analyzed to determine how many participants followed the CAP recommendation to preferentially use “integrated test systems” for laboratory diagnosis of LA (15). Findings for categorical (yes/no) questions were expressed as percentages, after exclusion of “not applicable” or skipped responses. Chi-Square analyses were used to assess potential differences in categorical data for NASCOLA and ECAT participants ($p < 0.05$ considered significant).

Results

From the combined membership of NASCOLA and ECAT, 113 laboratories responded to Q1, and 96 laboratories responded to Q2. LA testing algorithms were provided by 104 sites that participated in Q1.

LA assays performed in clinical laboratories

Information on the commonly performed LA tests is outlined in Table 2. Most laboratories performed a LA sensitive APTT and the dilute Russell's viper venom time (DRVVT), and used mixing studies to evaluate abnormal findings for these assays (Table 2). The dilute prothrombin time (dPT) and kaolin clotting time (KCT) were more commonly used to screen for LA by ECAT laboratories, and often without mixing studies (Table 2). Review of LA test algorithms from Q1 indicated that 32% of laboratories performed only a lupus sensitive APTT and DRVVT for LA screening. Most laboratories that performed the KCT (4/5) also performed a lupus sensitive APTT and DRVVT.

Most laboratories confirmed phospholipid dependence of LA by the DRVVT confirm method (Table 2), with individual laboratories using confirm and screening reagents from the same vendor. The majority of NASCOLA (67%) participants, but few ECAT participants (7%), used the Staclot® LA (Diagnostica Stago Inc., Asnières sur Seine, France) "integrated test system", which uses hexagonal phospholipid (incorporated into a mixing study), to assess phospholipid dependence (Table 2). The platelet neutralization procedure was used by a minority of laboratories (Table 2).

Most of the laboratories performed immunoassays for antiphospholipid antibodies. The majority (78%) tested for cardiolipin antibodies (IgG subtype 100%; IgM subtype 98%; IgA subtype 96%) whereas a smaller number (46%) tested for beta-2-glycoprotein I antibodies (IgG subtype 100%; IgM subtype 95%; IgA subtype 58%). Only a minority of laboratories tested for antibodies to prothrombin (9%), phosphatidylserine (13%), or annexin V (7%). None tested for antibodies to phosphatidylcholine.

Laboratory compliance with published LA testing recommendations

Figure 1 summarizes the data on clinical laboratory compliance with the major recommendations in the 1995 ISTH and the 2000 BCSH guidelines on LA testing. The data were evaluated by assessing LA algorithms (Q1) and specific questions about compliance (Q2). Based on the two questionnaires, some differences were seen in compliance with published recommendations consistent with reports from participants (in Q2) that they had changed their LA testing practices (32%) or the reporting of LA test results (23%). Some participants (20%) planned to further change their LA testing practices after participating in Q2.

Most laboratories confirmed that they had verified that the plasma used for LA testing had the recommended minimal platelet contamination (Fig. 1), although some reported that they did not verify plasma platelet counts on referred samples. Other pre-examination variables were not formally assessed by the questionnaires. Most laboratories performed a minimum of two laboratory tests to screen for LA, using methods based on different test principles, with at least one of the assays having a low phospholipid concentration (Fig. 1). Nonetheless, 50% of NASCOLA laboratories and 14% of ECAT laboratories indicated that they did single LA tests if requested, which does not comply with published recommendations. The majority of laboratories document the inhibitor effect on pooled normal plasma (Fig. 1). Most laboratories confirmed the phospholipid dependency of the inhibitor detected by LA tests (Fig. 1). As

recommended, most laboratories used confirmatory tests for LA, based on the method giving the abnormal result in LA screening tests (Fig. 1). Approximately half of the laboratories performed all routine coagulation tests (prothrombin time [PT], APTT, and thrombin time [TT]), suggested by the ISTH and BCSH guidelines to help exclude other coagulation abnormalities (including anticoagulant effects) as the reason for an abnormal LA test (Table 1). Among laboratories that performed only a PT and an APTT to help exclude other coagulopathies, some (4/15 sites) performed heparin assays (anti-Xa activity levels) to assess abnormalities suspicious of heparin. The majority of laboratories did not consider antiphospholipid antibodies as confirmatory assays for LA, as recommended in the ISTH guidelines (5) (Fig. 1). The poorest compliance (<35%) was seen for the ISTH recommendation to perform factor assays whenever there is a suspicion that a factor deficiency, or a factor inhibitor, is the cause of a positive LA test (Fig. 1), although most participants (79%) performed mixing studies to investigate for possible factor deficiencies.

Answers to specific queries, contained in either Q1 or Q2, were used to further evaluate how LA test mixing studies were performed, and if the methods used, and interpretation of findings, were in accordance with published recommendations. In Q2, most laboratories (96%) verified that their normal pooled plasma gave a normal result in LA tests evaluated by mixing studies with this plasma. Many (80%) laboratories had determined that the ratio of patient to normal plasma, used for mixing studies, had an acceptable sensitivity and specificity for LA prior to use, either by testing within their laboratory (38%), reviewing published literature (18%) or both procedures (24%). In Q1, most sites confirmed that they used one of the options described in the 1995 ISTH recommendations, to evaluate findings for LA test mixing studies (5). Specifically, the majority (70%) used the criterion of failure to correct to within the mean of the reference interval + 2 standard deviations as indicative of an inhibitor; 13% used the criterion of failure to correct within the mean + 3 standard deviations; and 36% used the criterion of failure to correct to within 5 seconds of the test result for normal pooled plasma. The criterion of a Rosner Index, exceeding 15 for mixing studies (5, 20, 21), was used by many (53%) ECAT laboratories, but few (17%) NASCOLA laboratories. The majority (86%) had determined their numeric cut off value for DRVVT screen mixing studies using samples from twenty to thirty normal subjects. More ECAT laboratories (39%), compared to NASCOLA laboratories (17%) reported their findings as a normalized DRVVT screen/confirm ratio, as recommended in the BCSH guideline (17). Recommendations made by CAP (15) for use of commercially integrated test systems, which incorporate a 1:1 mixing study directly in the test, were followed by nearly ten fold more NASCOLA laboratories than those from ECAT (Table 2).

The responses to specific queries, contained in Q2, were used to determine how laboratories excluded heparin as a cause of an abnormal LA test. Most laboratories (87%) used additional coagulation tests to exclude heparin when LA tests showed an abnormality that could represent heparin. The majority of NASCOLA laboratories (64%), but few ECAT laboratories (26%), neutralized the plasma to remove the heparin. Among the group that treated the plasma to neutralize heparin, a greater proportion of NASCOLA (58%) compared to ECAT (25%) laboratories repeated the abnormal LA

tests using the heparin neutralized sample. Some sites (n=18) that did not test for heparin used an interpretive comment to indicate that an abnormal result could be caused by heparin.

The analysis of Q2 indicated that the approaches used to exclude other coagulation abnormalities varied. Some laboratories (19%) indicated that they only performed factor assays when additional tests were approved by the client. Many (68%) used an interpretive comment to indicate that a factor deficiency and/or specific factor inhibitor should be excluded, if clinically indicated, when factor assays were not done or required client approval. The majority of laboratories that performed factor assays tested two or more dilutions of the plasma sample as recommended (NASCOLA 83%; ECAT 100%) (5). Most laboratories (59%) indicated that they performed a DRVVT screen 1:1 mixing study to minimize false positives due to factor deficiencies and oral anticoagulant therapy. One site had specific instructions on how to test samples for patients on oral anticoagulants with an INR greater than 1.5. However, none of the other participants provided information on how LA testing was modified for patients on oral anticoagulants. Few laboratories (6%) had procedures outlined in their LA testing algorithm for the investigation of discordant results.

In Q2, 50% of laboratories expressed the opinion that some LA testing recommendations needed to be updated. Specifically, laboratories suggested updates for recommendations that: 1) inhibitor activity should be documented by the effect of patient plasma on pooled normal plasma, using a ratio of patient to normal plasma with an established sensitivity and specificity; 2) confirmatory assays should be based on the method giving an abnormal screening assay; 3) routine clotting tests, such as the PT and APTT, should be performed to evaluate the possibility of other coagulation disorders that may interfere with the LA methodology; and 4) factor assays should be performed whenever there is suspicion of a specific factor deficiency or inhibitor, using two or more dilutions of the patient plasma to evaluate any factor assay.

Discussion

The goals of our international survey on clinical laboratory practices for LA testing were to determine the current procedures that laboratories used for LA testing and laboratory compliance with published recommendations and guidelines on LA testing (5, 15, 17). It is interesting that many laboratories used commercial assays (lupus sensitive APTT and a DRVVT) for diagnosing LA and that about one-third of laboratories used only the APTT and DRVVT for LA investigations. Laboratory compliance was high with the published recommendations to use: platelet poor plasma with $<10 \times 10^9$ platelets/l; two or more screening tests, representing different assay principles, to evaluate for LA; the test method giving an abnormal LA screen to confirm LA phospholipid dependency; and not to use immunoassays of antiphospholipid antibodies to confirm LA. Nonetheless, some laboratories performed single LA tests when requested by a client – a practice that is not in accordance with some published recommendations (5). Some sites changed practices after participating in Q1 to increase their compliance with published recommendations, although compliance remained poor for the recommendation to perform factor assays to

exclude factor deficiencies or factor inhibitors as the cause of abnormal LA tests, in part because additional testing often required client approval. Some laboratories expressed the opinion that LA testing recommendations needed to be updated, particularly for the ISTH recommendation that additional investigations be done to exclude other causes of an abnormal LA result. This probably reflects the current realities of diagnostic laboratory practice, where fiscal constraints, and an inability to add extra tests to an order without client approval, influence the testing performed. It is informative that some laboratories used interpretive comments to deal with these restrictions.

Published algorithms for the investigation of LA indicate that when correction is found in the mixing studies, factor assays should be performed (5, 17). Although the majority of laboratories (NASCOLA 75%; ECAT 83%) that participated in our study performed mixing studies, factor assays were not routinely performed in the investigation of a LA. It is concerning that some laboratories did not perform two or more dilutions for factor assays, as LA demonstrate “non-parallelism”, with higher levels of factor activity recovered at higher dilutions (22).

Our study indicated that most laboratories performed 1:1 mixing studies for LA tests in accordance with published recommendations (5, 17). However, recent literature has shown that there are limitations to 1:1 mixing studies performed in the investigation of LA (3, 23, 24). For example, the degree of correction in mixing studies is dependent on the APTT reagent sensitivity to individual factors and the factor levels contained in the normal pooled plasma used in the mix (23). To overcome this limitation and ensure correct interpretation of the finding, it has been recommended that laboratories determine the individual factor sensitivities for the LA test reagent and the factor levels in the normal plasma used for mixing studies (23). It has also been reported that weak lupus anticoagulants may be missed when performing mixing studies, leading to false negative results (23-25).

It has been recommended that LA testing not be performed using samples from patients on anticoagulants, including warfarin, if at all possible (15). An accurate laboratory diagnosis of LA is difficult when testing is done for patients on warfarin therapy (3, 17, 23, 24, 26). We found that most laboratories use a routine coagulation screening test (PT), in combination with 1:1 mixing studies, to follow up on abnormal DRVVT screens from warfarin therapy or other causes of the abnormal test result. None of the laboratory LA testing algorithms outlined other specific modifications for testing patients on warfarin. Some laboratories use an interpretive comment to indicate that positive DRVVT results may be the result of warfarin therapy, and that the test should be repeated off warfarin therapy to determine if the abnormality is a true positive (3). While mixing studies, on the DRVVT test and confirmatory assay, can also be helpful, it is recognized that a negative DRVVT ratio does not rule out the presence of a LA when testing is done during warfarin therapy (17, 24). Updated guidelines, and a follow-up questionnaire on how laboratories evaluate patients on warfarin for LA, might be warranted to ensure that the potential for false positive and false negative results are recognized.

The majority of laboratories that participated in this study had strategies to comply with the recommendations to exclude heparin as the cause of abnormal LA test findings, which included reporting results with an interpretive comment that indicated heparin could be the cause of an abnormal result. At present, most commercial DRVVT reagents neutralize up to 1 unit/ml unfractionated or low molecular weight heparin, which reduces the potential for false positive LA test abnormalities due to heparin in the DRVVT test system, for most samples (23). Awareness of these and other issues could have led some of our study participants to conclude that some recommendations for LA testing need to be updated.

It is interesting that the majority of laboratories that participated in our study performed immunoassays to detect cardiolipin antibodies whereas a smaller number tested for beta-2-glycoprotein I antibodies. This may, in part, reflect the uncertainties and emerging data about which antiphospholipid antibody test has the greatest clinical utility (11, 27-30). ISTH guidelines indicate that results of such solid phase assays should not be considered as confirmatory procedures for LA activity (5). Nonetheless, a number of guidelines have recommended performing immunoassays for antibodies to cardiolipin and/or beta-2 glycoprotein I antibodies as part of testing for LA and antiphospholipid antibodies (5, 15, 17, 19, 31, 32).

The important finding of our study was that most clinical laboratories report they follow the published recommendations (ISTH, BCSH and/or CAP) (5, 15, 17) on LA testing and diagnosis, although compliance with select recommendations is poor. Poor compliance may be due, in part, to existence of different guidelines, and perceptions about the scope of national or regional (BCSH, CAP etc.) guidelines compared to international guidelines (ISTH). Different views on regional guidelines may be the reason why more North American laboratories followed the CAP recommendation to use commercial, fully “integrated test systems” for LA diagnosis that incorporate all reagents necessary for screen, mix and confirmatory testing (such as the Staclot® LA). However, some commercial vendors of LA assays offer screen and confirm reagents, without detailed instructions on the use of mixing studies. This lack of “full integration” (incorporation of all reagents necessary for screen, mix and confirmatory LA testing) may be the reason why some laboratories do not perform mixing studies for DRVVT assays (Table 2).

A number of external quality assessment programs have evaluated the proficiency of laboratories in testing for LA (33-37) however these studies did not address relationships between laboratory performance on the exercise and compliance to published LA testing recommendations. In general, compliance with published recommendations is thought to be important for the quality of laboratory testing, as it generally correlates with better performance on external quality assessments of some laboratory methods (37, 38). Given the variability in LA testing practices among laboratories, it would be interesting to assess if laboratories correctly apply the published recommendations (outlined in Table 1) using proficiency challenges with different types of abnormal clinical samples. The observation that a significant number of laboratories that participated in our study modified practices to conform to LA testing recommendations suggests that questionnaires could be a useful component of external quality assessment programs. The

need for an update of the ISTH published recommendations for LA testing (as suggested by 50% of the participating laboratories in our study) and others (28) should be further investigated.

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Figure 1. Summary of data on participant compliance with ISTH and BCSH recommendations on LA testing. Results compare the percentages that complied, using data from Q1 and Q2. # indicates recommendations found in both ISTH and BCSH guidelines; § indicates information assessed only by Q2; * indicates a significant difference between Q1 and Q2.

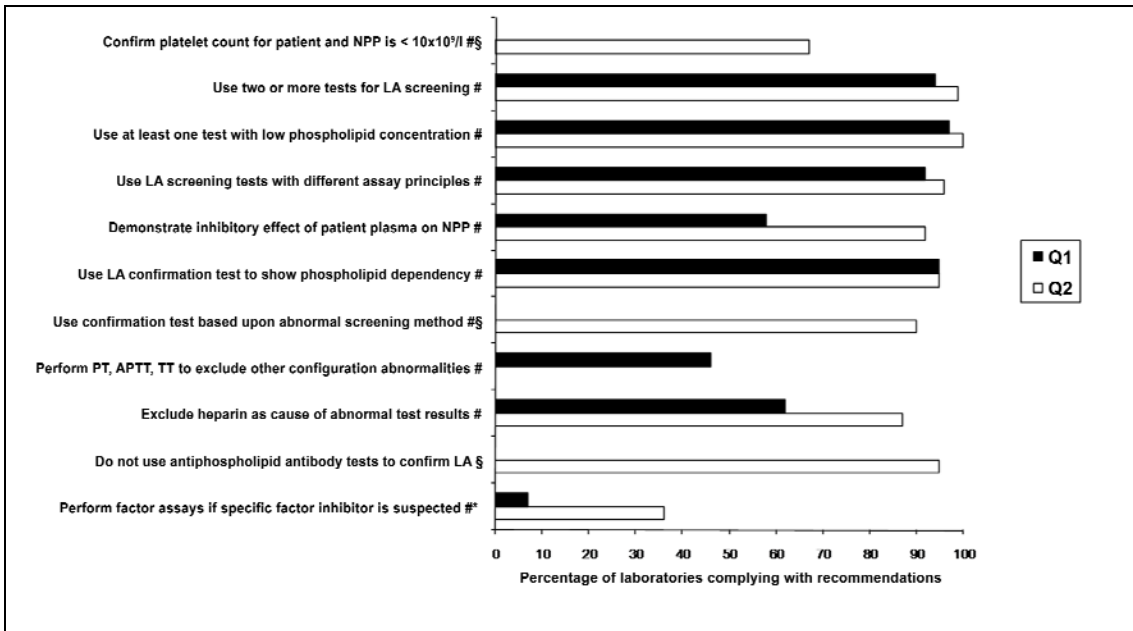


Table 1. Published recommendations for LA testing, including criteria for diagnosis of LA (summarized or cited from references) (5, 17).

ISTH (5)	BCSH (17)
<p>Criteria In order to make a diagnosis of LA, a sample should show each of the following:</p> <ol style="list-style-type: none"> 1. Prolongation of at least one phospholipid-dependent clotting test. 2. Evidence of inhibitory activity shown by the effect of patient plasma on normal pooled plasma. 3. Evidence that the inhibitory activity is dependent on phospholipid (which may be achieved by addition or alteration of phospholipid, hexagonal phase phospholipid, platelets, or platelet vesicles in the test system). 4. LAs must be carefully distinguished from other coagulopathies that may give similar laboratory results or may occur concurrently with LA. Specific factor assays and clinical history review may be helpful in differentiating LAs from these other possibilities. 	<p>Criteria Remain unchanged from the 1995 ISTH publication and include:</p> <ol style="list-style-type: none"> 1. Prolongation of a phospholipid-dependent coagulation test. 2. Evidence of an inhibitor demonstrated by mixing studies. 3. Confirmation of the phospholipid-dependent nature of the inhibitor.
<p>Recommendations</p> <ol style="list-style-type: none"> 1. The platelet count of both normal pooled plasma and patient plasma should be as "platelet-free" as possible (<10 x 10⁹/l). 2. Two or more tests should be used to screen for LA, at least one of which should be based on low phospholipid concentration, and the assays should represent different assay principles (eg, DRVVT and dAPTT). 3. Inhibitory activity should be shown by the effect of patient plasma on normal pooled plasma, and the sensitivity and specificity of the ratio of patient to normal plasma should be established before it is used routinely. 4. Confirmatory studies need to be performed to document the phospholipid dependence of the inhibitor. LA diagnosis should not be made on the basis of multiple abnormal screening assays and mixing studies alone. 5. Confirmatory assays should use the same assay principle as the screening test that was initially found to be abnormal. (eg, if the DRVVT is abnormal, a DRVVT-based confirmatory assay should be used). 6. Routine clotting tests such as the PT and APTT should be performed to evaluate the possibility that other coagulation disorders may be present that may interfere with LA methods, and a thrombin time may be helpful in detecting the presence of heparin. 7. Solid phase assays for antiphospholipid antibodies (eg, anticardiolipin antibodies) should not be considered as confirmatory procedures for LA activity. 8. Factor assays should be performed whenever there is suspicion of a specific factor deficiency or inhibitor, and two or more dilutions of patient plasma should be evaluated in any factor assay. 9. Retain the term "lupus anticoagulant" until the pathophysiology of these inhibitors is more fully delineated. 	<p>Recommendations</p> <ol style="list-style-type: none"> 1. Attention must be paid to preanalytical (pre-examination) variables. 2. A coagulation screen should be performed to identify unexpected factor deficiency or anticoagulant effect. 3. The APTT may be used as a screening test for LA. A sensitive reagent must be used. 4. If the APTT is prolonged, performance of mixing tests with normal plasma and/or a PNP is frequently informative. 5. A second test should also be used, preferably the KCT or the DRVVT with a correction procedure. 6. When results in these tests are equivocal, supplementary tests using different methods may be of help, e.g. other venom test or the TTI. 7. Immunoassay for IgG and IgM aCL (and/or possibly for β_2-GP-I antibodies) must also be performed.

Abbreviations: APTT = activated partial thromboplastin time; aCL = anticardiolipin; β_2 -GP-I = beta-2 glycoprotein I; dAPTT = dilute

activated partial thromboplastin time; DRVVT = dilute Russell's viper venom time; KCT = kaolin clotting time; LA = lupus

anticoagulant; PNP = platelet neutralization procedure; PT = prothrombin time; TTI = tissue thromboplastin inhibitor

Table 2. LA assays performed by laboratories. Results (shown as percentages of laboratories responding) show practices assessed by Q2.

Test	NASCOLA Participants (n=43)		ECAT Participants (n=42)	
	Performed Test	Evaluated abnormalities for this assay by mixing studies	Performed Test	Evaluated abnormalities for this assay by mixing studies
LA sensitive APTT reagent	88%	87%	94%	86%
DRVVT	98%	87%	90%	83%
dPT	21%	11%	50%	26%
dAPTT	5%	5%	10%	5%
KCT	7%	14%	47%	21%
DRVVT Confirm	98%	-	88%	-
Hexagonal Phospholipid (Staclot® LA)	67%	NA	7%	NA
PNP	33%	-	14%	-

Abbreviations: APTT = activated partial thromboplastin time; dAPTT = dilute APTT; dPT = dilute prothrombin time; DRVVT = dilute Russell's viper venom time; KCT = kaolin clotting time; PNP = platelet neutralization procedure; NA = not applicable as the commercial hexagonal phospholipid assay (Staclot® LA) has a mixing study with normal pooled plasma incorporated into the test.

What is known on this topic:

- Different guidelines have been published on lupus anticoagulant testing.
- Compliance with guidelines is known to influence performance on external quality challenges for some assays.

What this paper adds:

- Detailed information on current clinical laboratory practices for lupus anticoagulant testing and their compliance with published guidelines.
- Information on how laboratories use combinations of laboratory tests to evaluate lupus anticoagulants.
- Illustrates that clinical laboratory practices can be modified by questionnaires to improve compliance with published guidelines.