Clinical Significance of Different Antiphospholipid Antibodies in the WAPS (Warfarin in the Antiphospholipid Syndrome) Study

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Abstract

To assess the clinical significance of lupus anticoagulants (LA) and antiphospholipid antibodies (aPL) towards thrombosis and abortions, we measured them in 112 patients whose samples were available at enrolment in the WAPS study. ELISA and coagulation test values in the highest and lowest tertiles were compared. When considered separately, IgG antibodies to β2-glycoprotein I (aβ2GPI) and prothrombin (aPT) were associated with anamnestic arterial and venous thrombosis, respectively, and those to annexin AV (aAnAV) with abortions. IgM antibodies to protein S and the lupus ratio of the dilute prothrombin time were associated with prospective thrombosis. No other association for IgM antibodies was seen. LA-positive patients who carried aβ2GPI antibodies were at risk of anamnestic arterial and total thrombosis and aPT antibodies to that of anamnestic venous and total thrombosis. LA-positive patients who carried IgG aβ2GPI and aAnAV antibodies were at risk for both anamnestic abortion and prospective thrombosis. Overall, these data support the inclusion of aβ2GPI antibodies in and suggest the removal of anticardiolipin antibodies from the laboratory criteria of the antiphospholipid syndrome. They also suggest that the measurement of aPT and aAnAV antibodies is useful in some selected situations and that there is little role for IgM antibody detection.

Introduction

Arterial and venous thrombosis and recurrent abortions in combination with lupus anticoagulants (LA) and/or medium to high titres of IgG/IgM anti-cardiolipin (aCL) and anti-β2-glycoprotein I (aβ2-GPI) antibodies define the antiphospholipid syndrome (APS) (1). These antibodies are the best known and characterized antiphospholipid (aPL) antibodies, which, despite their name, are not directed against negatively-charged phospholipids, but recognize several (plasma) proteins with affinity for anionic phospholipids. Among them, β2-glycoprotein I (β2GPI) (2-4) and prothrombin (PT) (5, 6) are the antigenic targets of the majority of aPL antibodies, and subgroups of aβ2GPI and aPT antibodies display LA activity in vitro (3, 5, 7-9). The association of these antibodies with arterial and venous thrombosis has been widely investigated in the last two decades. In 2003, two systematic reviews of the literature on LA, aCL, aβ2GPI and aPT antibodies showed that LA are the strongest risk factors for both arterial and venous thrombosis, whereas such a role did not clearly emerge for the other antibodies, unless in some selected clinical scenarios (10, 11). Overall, IgG aCL antibodies at medium to high titre appeared possible risk factors of arterial thrombosis, aβ2GPI antibodies of venous thrombosis, whereas aPT antibodies did not seem to represent a significant
thrombotic risk factor. More recently, retrospective studies have found thrombosis to be associated with the presence of β2GPI-dependent LA activity (12) and with the combined positivity for LA, aCL and aβ2GPI antibodies (13). These data support the concept that the analysis of the aPL antibody profile, rather than of a single test, helps to establish which aPL-positive patients are at risk of thrombosis. Along this line, other so-called aPL antibodies, such as those directed to protein S (PS) (14) and annexin AV (AnAV) (15), have been studied for their association with thrombosis and miscarriage. Variable results have been reported, partly because of the retrospective design of most studies, which prevented from drawing firm conclusions.

In the present analysis, we explored the relationship between single/multiple positive tests for LA and IgG/IgM aCL, aβ2GPI, aPT, aPS and aAnAV antibodies and thrombosis and obstetric complications before and after recruitment in a subgroup of patients enrolled in the Warfarin in the Anti-Phospholipid Syndrome (WAPS) prospective, multicenter, International study (16).

**Patients and Methods**

**Patients**

This study was undertaken in the setting of the WAPS study, an International and prospective registry which enrolled 462 patients with persistent LA and/or moderate to high positive aCL antibodies from 26 centres in Italy, Norway, Poland, Argentina and Czechoslovakia (16). Diagnosis of LA and aCL antibodies was performed locally by each participating Centre (17, 18). No other aPL antibody measurement was required to participate in the WAPS study. Thus, we were unaware of the aPL status of the patients apart from their LA and/or aCL persistent positivity.

All patients gave their written informed consent to participate in the clinical study and to blood testing. The present study included the 112 patients whose plasma and/or serum samples were centralized at the Ospedali Riuniti of Bergamo (Italy). The study was approved by the Ethical Committee of each participating Centre. We measured aCL, aβ2-GPI, aPT, aPS and aAnAV antibodies in all of them. The complete series of three coagulation tests (i.e., activated partial thromboplastin time, APTT, dilute Russell’s viper venom time, RVVT, dilute prothrombin time, DPT) was performed in the plasma of 108 patients; the APTT- and the RVVT-, but not the DPT-based tests were carried out in the plasma of two patients and for the remaining two cases plasma was not available for coagulation tests.

**Endpoints**
The analysis was aimed at assessing the association between the antibodies of interest (see below) and 1) diagnosis of APS (e.g., any anamnestic thrombotic and obstetric event qualifying for the syndrome) at recruitment; 2) anamnestic total, arterial and venous thrombosis; 3) prospective thrombosis; 4) abortions before recruitment.

All diagnoses of thrombosis (stroke, transient ischemic attack, deep vein thrombosis, pulmonary embolism) had to be objectively documented (for clinical details, see ref. 16). Thrombotic events during follow-up have been blinded validated by an ad hoc committee of experts. The criteria for and classification of these events were prespecified (16).

Measurement of aPL antibodies

IgG and IgM aCL, aβ2GPI and aPT antibodies were measured by commercially available ELISA (Asserachrom APA, Asserachrom Anti-β2GPI and Asserachrom Anti-Prothrombin, respectively, all kindly provided by Diagnostica Stago, Asnieres, France). ELISA results were expressed in GPL and MPL units according to the manufacturer’s instructions. Asserachrom APA is a mixture of three phospholipids – among which cardiolipin - coated on the plate as solid phase antigen. It is also a β2-GPI-dependent ELISA. For both these reasons, we used this assay to measure aCL antibodies.

IgG and IgM aAnV and aPS antibodies were measured by prototype ELISAs (both kindly provided by Diagnostica Stago). Results were expressed in mOD.

Measurement of LA

LA were detected by Lupus Ratio (LR) tests, which are quantitative assays for LA that integrate screening, mixing and confirmatory procedures into one run. They are based on one of the phospholipid-dependent clotting principles: APTT, RVVT or DPT, respectively (19-21). For each of the three tests, in-house reagents with dilutions of crude cephalin from porcine brain (a generous gift from Axis-Shield PoC AS, Oslo, Norway) were used. In the APTT-based lupus ratio (LR) test, crude cephalin diluted 1/50 and 1/800 in Owren’s buffer, respectively, were mixed 1:1 with ellagic acid as activator (final concentration 6 mg/l). For the DRVVT-based LR test, crude cephalin was diluted 1/200 and 1/10,000, respectively. Russell viper venom (Sigma-Aldrich Norway, A/S, Oslo, Norway) was diluted in imidazole buffer with 1% bovine serum albumin. The reagents for the DPT-based LR test were prepared with recombinant thromboplastin (Innovin, Dade Behring, Marburg, Germany) diluted 1:200 in tris buffered saline (final dilution). Diluted recombinant thromboplastin was used as reagent with low phospholipid concentration. For a reagent with high phospholipid
concentration, crude cephalin (final dilution 1:200) was added to the thromboplastin (21). Regardless of which clotting principle that was used, the patient’s plasma was mixed 1:1 with pooled normal plasma before testing. For each of the three clotting tests, clotting times were then registered with the reagents with low and high phospholipid concentrations, respectively. The clotting time with the reagent with low phospholipid concentration was then divided by the clotting time obtained with the reagent at high phospholipid concentration. The ratio was normalized by dividing with the corresponding ratio of the normal pooled plasma. The final result is the LR of that patient’s plasma.

Statistical analysis

Continuous data are expressed as median and interquartile range. Discrete variables are presented as percentages. Clinically meaningful cut-off values have been chosen to categorize aCL antibodies (≥ 40 units).

For their association with the endpoints listed above, values of IgG and IgM antibodies assessed with ELISA have been analyzed as statistical tertiles, whereas upper normal limit values of LR for each coagulation test, corresponding to the 97.5 percentile of a normal population (APPT ≥ 1.10, RVVT ≥ 1.11, DPT ≥ 1.08) (20), have been compared with those below the limit.

Clotting assays were also analyzed assessing the effect of one-unit increases of the LR above the upper normal limit. LA positivity was defined by the value of the LR above the upper normal limit of at least one of the following tests: APTT, RVV, and DPT. The relationship between endpoints and selected antibodies have been considered separately as well as according to their combinations.

Age- and gender-adjusted multivariable logistic models have been fitted with the endpoints and the selected antibodies alone and in combination as explanatory variables to assess their independent, predictive role. Results are given as odds ratios (OR) along with their 95% Confidence Interval (CI). A two-sided P value < 0.05 was considered as statistically significant. Because of the explorative nature of the analysis, no correction for multiplicity of tests was performed.

Results

Clinical characteristics of patients recruited in the study

The main demographic, clinical and laboratory features of the sample population are reported in Table 1. Eighty seven patients were diagnosed with APS because they had thrombotic and/or
obstetric complications, while aPL antibodies were present in 25 patients either alone or in combination with clinical manifestations other than those qualifying for APS.

At the time of enrolment, 39 (34.8%) and 23 (20.5%) patients were on anticoagulant and antiplatelet therapy, respectively. Forty-one (36.6%) out of 112 patients entered the randomized trial: 19 received high-intensity warfarin and 22 continued the conventional therapy (16).

During a median follow-up of 3.67 years, 15 (13.4%) patients had a thrombotic event: deep vein thrombosis in seven patients (one of them experienced three events), transient ischemic attacks in four cases, ischemic cerebral strokes in three patients and non-fatal pulmonary embolism in one case. Two out of the 15 patients with thrombosis during follow-up experienced an abortion, too.

Seven patients had a thrombotic event (4 deep vein thromboses, 1 stroke and 2 transient ischemic attacks) while they were not receiving an antithrombotic therapy (one of them had withdrawn warfarin three weeks before recurrence of deep vein thrombosis).

Prevalence and tertile distribution of various aPL antibodies

Table 2 reports the values of ranges, medians, and lower/upper limits of the highest tertile of both IgG and IgM antibodies measured in the patients’ population for the various tests.

The LR exceeded the upper normal limits in 72, 71, and 92 patients for the APTT-, RVVT-, and DPT-based tests, respectively. Ninety-eight patients (87.5%) were LA-positive since they had at least one abnormal coagulation test.

Clinical associations of various aPL antibodies

Figure 1 shows the relationships between the outcome events measured before and after recruitment in the study and IgG aβ2-GPI, IgG aPT and IgG aAnAV antibodies which have been found to be statistically significant. All positive and negative correlations are reported in Table 3, which is available in the on-line version of the manuscript.

As to the G isotype, various statistically significant results have been found when we compared the risk of event in the upper tertile with the lower one. In particular, aAnAV antibodies were associated with a 9-fold higher risk of abortion, aPT antibodies were associated with a 3 to 4-fold higher probability of retrospective thrombosis in the study, while the probability of full APS diagnosis was 4-fold. As to aβ2GPI antibodies, they were associated with a 3 to 4-fold higher probability of retrospective thrombosis, a 10-fold higher risk of abortion, and a 16-fold higher risk of APS. aPS
antibodies in the highest tertile were associated with a significantly reduced risk of anamnestic total thrombosis (OR 0.28, 95% CI 0.09-0.91, \(p=0.0349\)).

The DPT-based assay with a LR above the upper normal limit was also significantly associated with APS (OR 6.62, 95% CI 1.73-25.36, \(p=0.0059\)) and anamnestic thrombosis (OR 4.51, 95% CI 1.22-16.67, \(p=0.0239\)). We also observed a 2.5 times higher risk of prospective thrombosis for each unit increase of the DPT-based LR assay (OR 2.54, 95% CI 1.05-6.19, \(p=0.0395\)). No other coagulation test showed significant associations.

No significant association was seen between the M isotype and anamnestic thrombotic or obstetric events. IgM aPS antibodies in the highest tertile were associated with a significantly reduced risk of anamnestic arterial thrombosis (OR 0.21, 95% CI 0.07-0.67, \(p=0.0349\)). Conversely, the presence of IgM aPS antibodies in the highest tertile was associated with a significantly high risk of prospective thrombosis (OR 6.58, 95% CI 1.19-36.36, \(p=0.0308\)).

**Contribution of positivity to multiple aPL antibodies to the risk of thrombosis and abortions of LA-positive and high levels of one or more of the IgG antibodies**

Figure 2 shows the significant relationships between the outcome events measured before and after recruitment in the study in LA-positive patients with high levels (upper tertile) of one or more antibodies. Because we obtained a statistically significant result only for one test involving IgM antibodies (see previous paragraph), we limited the analysis to the G isotype. All positive and negative correlations are reported in Table 4, which is available in the on-line version of the manuscript.

According to the aforementioned, we had available 31 combinations of laboratory variables ranging from a minimum of two (i.e., LA-positive patients who carried only one IgG antibody in the highest tertile) to a maximum of six (i.e., LA-positive patients who carried all the five IgG antibodies in the highest tertile). Overall, 9 (5.8%) out of 155 combinations that have been analyzed reached the formal level for statistical significance (\(P<0.05\)).

LA-positive patients belonging to the upper tertile of aAnAv or aPT antibodies had an almost 3- to 4-fold higher risk of thrombosis. LA-positive patients belonging to the upper tertile of aAnAv antibodies had a 4-fold higher risk of abortion.

LA-positive patients belonging to the upper tertile of a\(\beta\)2GPI antibodies had an almost 2- to 4-fold higher risk of thrombosis.
LA-positive patients belonging to the upper tertile of aAnAv and aβ2GPI antibodies had an almost 5- to 7-fold higher risk of prospective thrombosis and abortion. Finally, LA-positive patients belonging to the upper tertile of aAnAv, aβ2GPI, aCL antibodies had an almost 8-fold higher risk of abortion.

Discussion

At the beginning of 2006, an International panel of experts established by majority the inclusion of aβ2GPI antibodies among the criteria of APS besides LA and aCL antibodies (1). The same panel established the inclusion of aPT and antiphosphatidylethanolamine antibodies be premature, due to the insufficient amount of available evidence. The panel neither took into account the role of other aPL antibodies as laboratory criteria, nor considered the significance of aPL antibodies as predictors of occurrence/recurrence of the APS events. Our study - performed in the setting of the WAPS study (16) - gave us the possibility to investigate the role of five aPL antibodies and three coagulation tests as diagnostic criteria and predictors of thrombosis and obstetric complications of the APS. We considered the clinical significance of each ELISA and coagulation test and evaluated the contribution of ELISA tests to the risk conferred by the presence of LA. Our study confirms the usefulness of the inclusion of IgG aβ2GPI antibodies among the laboratory diagnostic criteria of APS, since we found that levels of these antibodies in the highest tertile were significantly associated with all the clinical endpoints qualifying for the syndrome. Conversely, aCL antibodies did not show any significant association. These observations are well in agreement with the results of a systematic review of the literature on APS (11), which reported a higher frequency of significant associations with thrombosis for aβ2GPI than aCL antibodies. This difference is apparently difficult to reconcile to the notion that ELISAs for aCL detection are β2GPI-dependent and should, therefore, measure aβ2GPI antibodies. In the real case, measurements of aCL and aβ2GPI antibodies are only partly overlapping, and the presence of the antibodies may be detected by one but not the other ELISA system. Several reasons account for this discrepancy: i. according to the source of β2GPI in the assay, aCL ELISAs may measure antibodies directed against bovine β2GPI, which are clinically irrelevant; ii. since cardiolipin or a mixture of anionic phospholipids are coated on the aCL ELISA plate, antibodies against phospholipid-binding proteins other than β2GPI may be measured in this assay; iii. aβ2GPI ELISAs allow the measurement of antibodies directed against all the potential binding sites on the molecule, whereas aCL ELISA does not allow the detection of antibodies directed against the fifth domain, which is already engaged in the binding to
phospholipids. Based on these clinical and laboratory observations, we may foresee that the next update will retain aβ2GPI antibodies and discard aCL antibodies as laboratory criteria of APS.

Our analysis suggests the possibility that aPT and aAnAV antibodies are potential candidates as laboratory criteria of APS, at least in some selected situations. In fact, the former antibodies were associated with (venous) thrombotic events, which is a somewhat unexpected finding, based on the results of a systematic review of the literature (11). On the other side, this is well in keeping with the results of “in vitro” model systems, which show the ability of aPT antibodies to interfere with the anticoagulant protein C pathway (22) and to promote thrombin generation (23). It is also in agreement with the results of a recent prospective study, which reported IgG aPT and aβ2GPI antibodies to be independent risk factors of thrombosis recurrence (24). aAnAV antibodies were found to be associated with the obstetric complications of the APS. The observation that AnAV is the main anticoagulant substance present in the placenta (25) provides the plausible pathophysiologic rationale. However, care must be taken before these data are generalized, because a large, retrospective study reported only a non-significant trend for the association between aAnAV antibodies and miscarriage (26).

By logistic regression age- and gender-adjusted, we found that IgM aPS antibodies were significantly associated with prospective thrombosis. aPS antibodies are reported in children during or after (viral) infections, such as varicella and chicken pox (27). They are commonly transient, and present together with LA and only in a few cases they cause purpura fulminans (28). These clinical scenarios are very selective and unusual, which makes the routine detection of IgM aPS antibodies of little use in adult patients suspected of suffering from APS. Even more, the presence of aPS antibodies of both isotypes seems to have a protective effect against anamnestic thrombosis. Thus, the evidence so far available about aPS antibodies is rather conflicting, implying that their significance is still doubtful and that their measurement is presently not recommended outside of clinical studies. No other significant association was observed between IgM aPL antibodies and thrombosis or obstetric complications. These data are, again, in line with the results of two systematic reviews, which reported IgM aCL, aβ2GPI and aPT antibodies to be less often associated than IgG antibodies with the clinical events of the APS (10, 11). Very few studies included in these reviews analyzed the relationship between thrombosis and the titer of IgM aCL antibodies. It appeared that the higher the titer, the higher the possibility to find significant correlations. However, the amount of available information was too scanty and limited to allow any meaningful conclusion. A recent large, prospective study on IgG and IgM aCL, aβ2GPI and aPT antibodies did not find any significant association between the M isotype and thrombosis, even when the cut-off of 40 units was used (24). Because of the low risk to miss the occasional patient
whose APS is characterized by the isolated presence of IgM antibodies, we suggest to limit the routine measurement of aPL antibodies to the G isotype, at least until well-designed studies establish if and which role IgM aPL antibodies have in the setting of APS. This suggestion goes towards the simplification of the laboratory workout of patients suspected of suffering from APS and represents a step beyond the indications of the International panel of experts to measure aCL and αβ2GPI antibodies of both the G and M isotype (1).

In the original WAPS study (16), LA detection was performed locally by each participating Centre, and very many different tests, reagents and instrumentations were used. This made virtually impossible to investigate the clinical significance and contribution of each single coagulation test. In the present study plasma samples were centralized in order to perform a homogeneous coagulation screening. The use of three integrated assays allowed us to analyse plasmas from patients on oral anticoagulation and to detect antibodies with different specificities. Because the great majority (about 90%) of our patients had at least one of these assays abnormal, we could not establish the role of LA positivity as an independent risk factor of thrombosis. When the three assays were analyzed separately, the DPT-based LR test was significantly associated with both anamnestic and prospective thrombosis. In essence, this is a prothrombin time-based assay performed with diluted thromboplastin: according to the type of reagent, the DPT is highly sensitive and specific for the presence of LA (29), caused by both αβ2GPI (30, 31) and aPT antibodies (31).

The analysis was repeated to investigate the contribution of IgG aPL antibodies measured by ELISA to the risk of thrombosis conferred by LA. Again, aCL antibodies gave a very marginal contribution, whereas αβ2GPI antibodies were associated, alone, or in various combinations, with the thrombotic and obstetric events of APS. In particular, their presence together with aAnAV antibodies was a risk factor for prospective thrombosis. Also aPT antibodies contributed to the risk of thrombosis. aAnAV antibodies alone contributed to the risk of abortions. In general, the risk of event increased with the number of positive ELISA tests.

The results of our study must be viewed critically, in the light of its limitations. Firstly, samples were taken at enrolment in the WAPS trial and serial determinations during follow-up were not available. Secondly, a substantial number of patients were on antithrombotic drugs during the study period, which influenced the incidence of thrombosis (16, 32-34) and, therefore, affected the strength of associations between laboratory and clinical endpoints. This is, at least partly, the reason why most significant associations were retrospective. Thirdly, the laboratory tests to detect aPL antibodies are far from a proper standardization. The assays we used are no exception, although care was taken to centralize both the coagulation and the ELISA determinations. As we measured aCL antibodies by an assay which utilizes a mixture of phospholipids rather than pure cardiolipin as
solid phase antigen, we cannot rule out the possibility that another ELISA may lead to substantially different results and associations. Also, the highly selected nature of our patients’ population - more than three quarters of them suffered from APS - may have influenced the reported associations. Finally, because of the explorative approach of the analysis, we did not allow for multiplicity of tests. Therefore, we cannot exclude that play of chance could be the explanation of some of the results, but the rarity of the disease along with the bounty of specific tests that were available in the database made this approach a unique opportunity, though scientifically speculative, to produce stimulating results.

In conclusion, this study supports the inclusion of aβ2GPI antibodies among the laboratory criteria of APS (1). Based on our data and on the literature published in the last few years, we go even further, and propose to replace aCL measurement by that of aβ2GPI antibodies and to explore the possibility - by means of “ad hoc” studies - to limit antibody detection to the G isotype. As the measurement of aPT and aAnAV antibodies appeared useful in some selected situations, we prompt further investigation to establish if and to which extent they also can be considered among such criteria.

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M. Galli designed research, analyzed data and wrote manuscript;
G. Borrelli, R.M. Marfisi, R. Marchioli analyzed data and wrote manuscript;
E.M. Jacobsen, F. Wisloff performed coagulation tests, analyzed data and wrote manuscript;
G. Finazzi, O. Morboeuf, T. Barbui wrote manuscript;
S. Marziali performed ELISA tests.
References


Table 1. Main demographic, clinical and laboratory features of 112 patients with aPL antibodies at entry in the WAPS study.

<table>
<thead>
<tr>
<th>Features</th>
<th>Numbers (Prevalence, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
</tr>
<tr>
<td>M / F</td>
<td>24 / 88</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>42</td>
</tr>
<tr>
<td>Range</td>
<td>23 – 83</td>
</tr>
<tr>
<td><strong>Autoimmune diseases</strong></td>
<td>32 (28.6)</td>
</tr>
<tr>
<td>Systemic lupus erythematosus</td>
<td>21</td>
</tr>
<tr>
<td>Autoimmune haemolytic anaemia</td>
<td>5</td>
</tr>
<tr>
<td>Autoimmune thyroyditis</td>
<td>2</td>
</tr>
<tr>
<td>Sjogren’s syndrome</td>
<td>2</td>
</tr>
<tr>
<td>Miscellane</td>
<td>8</td>
</tr>
<tr>
<td><strong>Anamnestic thrombosis</strong></td>
<td>81 (72.3)</td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>46</td>
</tr>
<tr>
<td>Arterial thrombosis</td>
<td>30</td>
</tr>
<tr>
<td>Both deep vein and arterial thrombosis</td>
<td>5</td>
</tr>
<tr>
<td><strong>Anamnestic spontaneous miscarriage (n ≥ 1)</strong></td>
<td>17 (19.3)</td>
</tr>
<tr>
<td><strong>Antiphospholipid syndrome</strong></td>
<td>87 (77.7)</td>
</tr>
<tr>
<td><strong>LA</strong>*</td>
<td>91 (81.3)</td>
</tr>
<tr>
<td><strong>aCL antibodies (number of patients tested, 104)</strong></td>
<td>57** (54.8)</td>
</tr>
<tr>
<td>IgG ≥ 40 GPL units</td>
<td>49</td>
</tr>
<tr>
<td>IgM ≥ 40 MPL units</td>
<td>14</td>
</tr>
</tbody>
</table>

*Results of LA and aCL antibodies refer to assays performed locally at each participating Centre; ** six patients had both aCL isotypes ≥ 40 units
**Table 2.** Measurement of IgG and IgM aPL antibodies of 112 patients in samples taken at entry in the WAPS study

<table>
<thead>
<tr>
<th>Antibody</th>
<th>Range*</th>
<th>Median*</th>
<th>Highest tertile, range*</th>
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</thead>
<tbody>
<tr>
<td>aCL, units</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IgG</td>
<td>3-200</td>
<td>18</td>
<td>40-200</td>
</tr>
<tr>
<td>IgM</td>
<td>1-200</td>
<td>5</td>
<td>7-200</td>
</tr>
<tr>
<td>aβ2-GPI, units</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IgG</td>
<td>1-200</td>
<td>11</td>
<td>27-200</td>
</tr>
<tr>
<td>IgM</td>
<td>2-200</td>
<td>8</td>
<td>14-200</td>
</tr>
<tr>
<td>aPT, units</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IgG</td>
<td>1-70</td>
<td>4</td>
<td>5-70</td>
</tr>
<tr>
<td>IgM</td>
<td>1-200</td>
<td>4</td>
<td>6-200</td>
</tr>
<tr>
<td>aPS, mOD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IgG</td>
<td>43-214</td>
<td>93</td>
<td>104-214</td>
</tr>
<tr>
<td>IgM</td>
<td>53-1462</td>
<td>97</td>
<td>111-1462</td>
</tr>
<tr>
<td>aAnAV, mOD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IgG</td>
<td>63-387</td>
<td>105</td>
<td>130-387</td>
</tr>
<tr>
<td>IgM</td>
<td>47-1526</td>
<td>106</td>
<td>124-1526</td>
</tr>
</tbody>
</table>

*The data refer to the values measured in the patients’ population.*
Figure 1. Age- and gender-adjusted significant associations of various IgG aPL antibodies in the upper tertile with anamnestic clinical endpoints. No significant association was found between IgM antibodies in the upper tertile and anamnestic clinical endpoints. IgG and IgM antibodies were measured at enrolment of 112 patients in the WAPS study. In brackets the numbers of patients with events on the number of patients with antibodies in the highest tertile are reported.

§APS means that arterial thrombosis, venous thrombosis and obstetric events were combined.

*Total thrombosis means that anamnestic arterial and venous thrombosis were combined.
**Figure 2.** Contribution of IgG aPL antibodies in the upper tertile to the risk of thrombosis and abortions of LA-positive patients enrolled in the WAPS study. In brackets the numbers of patients with events on the number of patients with LA-positive and IgG antibody in the highest tertile are reported. Analysis was age- and gender-adjusted. In brackets the numbers of patients with events on the number of LA positive patients with antibodies in the highest tertile are reported.

*Total thrombosis means that anamnestic arterial and venous thrombosis were combined.*
Clinical significance of different antiphospholipid antibodies in the WAPS (Warfarin in the Anti-Phospholipid Syndrome) study

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