Antiphospholipid Antibodies and Recurrent Thrombotic Events: Persistence and Portfolio

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Key Words
Antiphospholipid antibodies · Ischemic stroke · Thrombosis · Coagulation · Outcomes · Epidemiology · Recurrent stroke risk

Abstract
Background: There are very limited prospective data on the significance of persistent antiphospholipid antibodies (aPL) and recurrent thrombo-occlusive events (TOEs). We investigated the prognostic value of (1) 2 newer aPL assays, (2) an aPL portfolio and (3) persistent aPL positivity following stroke. Methods: A total of 1,770 subjects from the APASS-WARSS study underwent further aPL testing for antibodies to phosphatidylserine (aPS) and anti-β2-glycoprotein-I (anti-β2GPI) from stored sera. Follow-up aPL status was also tested in a subset of subjects. Primary analysis was based on time to any TOE (ischemic stroke, myocardial infarction, transient ischemic attack, deep vein thrombosis, pulmonary embolism or systemic arterial occlusion)/death at 2 years. Cox proportional hazard analyses assessed whether aPL independently related to outcome. Results: Persistent anti-β2GPI decreased the time to TOE/death after adjustment for potential confounders (hazards ratio (HR) 2.86, 95% CI 1.21–6.76, p = 0.017). When persistent anti-β2GPI was combined with another persistently positive aPL, time to TOE/death was also reduced (HR 3.79, 95% CI 1.18–12.14, p = 0.025). Neither persistent anticardiolipin antibodies nor persistent aPS alone nor a single positive anti-β2GPI nor aPS was associated with decreased time to TOE/death. No single positive aPL, portfolio of baseline aPL or any persistent aPL increased

C.F.A. and S.R.L. contributed equally to the manuscript.
the rate of TOE/death. **Conclusions:** Rates of TOE/death were not influenced by aPL results at baseline or follow-up. Persistent anti-β₂GPI alone, and with persistent second aPL, was independently associated with decreased time to TOE/death. Persistent aPL, an aPL portfolio and newer aPL in ischemic stroke patients are not helpful in predicting an increased rate of recurrent TOEs.

**Introduction**

Antiphospholipid antibodies (aPL) have been associated with venous and arterial thrombo-occlusive events (TOEs) [1–5]. A single aPL has been associated with initial stroke [6–9] but was not predictive of recurrent TOE/death [10]. Persistent aPL in young stroke patients was predictive of recurrent stroke [11].

The WARSS-APASS collaboration [10] found that ischemic stroke patients positive for both lupus anticoagulant (LA) and anticardiolipin antibodies (aCL) at baseline had higher risk for TOE/death than subjects without aPL. Since the WARSS-APASS study, standardized assays for 2 new aPL have been developed potentially more biologically relevant for predicting TOE [12–25]. β₂-Glycoprotein-I (β₂GPI) has been found to be the most likely antigenic target of the aPL antibodies [23]. In addition, antibodies to phosphatidylserine (aPS) have been independently associated with ischemic stroke [25]. Persistence of aPL over time may confer a higher risk for TOE [11, 26] as does positivity on more than 1 aPL assay (‘portfolio’) [27].

We therefore re-tested stored sera of WARSS-APASS study subjects. In particular, we looked for the presence of anti-β₂GPI and aPS at baseline, and for persistence of these and aCL in predicting subsequent TOE/death. We also sought to determine whether an aPL portfolio increased the risk of TOE/death.

**Methods**

**Subjects**

A total of 2,206 patients were recruited into WARSS [28]. Of these, 1,770 of 1,954 (91%) APASS-eligible WARSS patients consented to participate in the APASS-WARSS study. The consent form was written and approved with knowledge that additional ‘antibodies/proteins’ could be tested apart from aCL/LA. All patients who participated in APASS were eligible for further testing. Stored serum samples were approved for further aPL testing by all but one of the APASS Centers’ Institutional Review Boards (Appendix).

**Sera Samples**

aPL testing was performed from previously unthawed sera stored at –70°C. Samples from baseline as well as 12 and 24 months post stroke had been stored. Plasma (LA testing) was not drawn/ stored at follow-up for concern of unmasking treatment arm (warfarin) of the primary WARSS study.

**aPL Assays**

Baseline sera were tested for anti-β₂GPI and aPS. Also, follow-up aPL status for all aPL was assessed from sera at 12 and 24 months post stroke.

As previously reported [10], aPL cutoff values were established by the assay manufacturers. Positive cutoff values were aCL: IgG >21 GPL (IgG phospholipids units) and IgM >12 MPL. Anti-β₂GPI was measured via commercially available ELISA (Innova Diagnostics, USA) and previously used [15]. Cutoffs for normal/ negative were IgG ≤20 and IgM ≤20. aPS (IgG/M isotypes) were measured by commercial kit (REAESD®). Cutoffs for normal/negative were IgG ≤16 and IgM ≤22.

**Persistence**

aPL persistence was defined as positive at all time-points for which that assay was tested. Conversely, transient positivity was defined as positive at baseline in patients who then had at least one subsequent negative assay.

**Primary Outcome**

TOE as previously defined [10, 28] as occurrence of death (any cause) or any TOE – ischemic stroke, myocardial infarction (MI), transient ischemic attack (TIA), deep venous thrombosis, pulmonary embolism, systemic visceral or peripheral arterial embolism. All TOEs were independently adjudicated, blinded to treatment and aPL status.

**Pre-Specified Secondary Analyses**

We hypothesized (1) positive aPL would correlate with decreased time to TOE/death, (2) persistent aPL would confer a stronger correlation, (3) increasing number of positive aPL assays would increase TOE/death risk and (4) positivity on one aPL would correlate with positivity on other aPL assays.

**Statistical Analysis**

The primary analysis was time to TOE/death at 2 years. Cox proportional hazard analyses assessed the association between time to TOE and aPL. Multivariate analyses assessed whether aPL independently relates to outcome (TOE) after adjustment for potential confounders and are presented as OR and their 95% CIs. Baseline demographic and traditional stroke risk factors that relate to both aPL status and outcome were considered for incorporation into the model. Potential confounders were entered simultaneously into a discrete time Cox proportional hazards model to obtain the effect of aPL positivity (log relative hazard) adjusted for the potential confounding effects of these covariates.

Treatment differences were tested with an interaction term to assess whether significant differences existed for the effect of aPL in patients treated with warfarin or aspirin. An interaction between aPL and treatment was considered significant when the p value for interaction was ≤0.10. (In all analyses of interactions, the main effects that are combined to form the interaction are in-
If no significant interaction was found, the 2 treatment arms were combined. If the treatment interaction was significant, separate analyses were performed for each treatment arm. All statistical analyses were conducted using SAS software (SAS/STAT software, version 9.2; SAS Institute, Cary, N.C., USA).

To test if missing data at 12 and 24 months after stroke were independently associated with TOE status, baseline anti-β 2 GPI or other observed covariates, a logistic regression model with a missing indicator as an outcome was estimated [29, 30]. Association between missingness/dropping out and these variables was measured using ORs and corresponding 95% CIs.

We assessed concordance of aPL positivity over time and agreement among the 3 assays (aCL, aPS and anti-β 2 GPI) using kappa statistics.

### Results

#### Baseline Demographics

Baseline demographics of subjects assayed for anti-β 2 GPI are presented in table 1, along with months 12 and 24 results. While the number of subjects assayed for aPS and aCL are slightly different, the percentages are essentially identical. Subjects with follow-up assays were similar to those without follow-up testing at month 12; in the month 24 follow-up groups, subjects not tested were less likely to have a sedentary lifestyle, be married and more likely to have diabetes.

#### Baseline Demographic Factors Associated with aPL Status

For each of the 3 aPL assays, we found the following associated factors: for anti-β 2 GPI being white; for aCL they were age, white, alcohol, ever smoked, obese, history of hypertension and systolic blood pressure; and for aPS they were age, white, college education, alcohol and systolic blood pressure.

#### aPL Persistence

Percentage of subjects testing positive on each aPL at each time point is presented in table 2: 38 of 147 subjects anti-β 2 GPI positive at baseline (25.9%) showed persistence, while 24 of 147 subjects (16.3%) were transiently positive. The remaining 85 subjects who were positive at baseline did not have follow-up testing. One subject with a missing anti-β 2 GPI baseline assay was positive at both months 12 and 24, and was therefore persistently positive.
No subjects negative at baseline became positive at both months 12 and 24. For aPS, 36 of 115 (31.3%) demonstrated persistence while 20 of 115 (17.4%) were transiently positive. One patient missing aPS baseline was positive at both follow-ups. One subject who was aPS negative at baseline became positive at both follow-ups.

For aCL, 143 of 485 subjects (29.5%) showed persistence while 171 of 485 (35.3%) were transiently positive. Fifteen aCL negative at baseline subjects were positive at both follow-ups; however, none missing the baseline assay were positive at both follow-ups. Twenty patients were persistently anti-β2 GPI positive and persistently positive for either aPS or aCL.

### Clinical End Points

There were 394 TOEs among 1,624 patients tested for anti-β2 GPI, 394 among 1,625 patients tested for aPS and 422 among 1,753 patients tested for aCL. There were 9 TOEs in 39 patients persistently positive for anti-β2 GPI: 5 cerebrovascular (1 recurrent stroke and 4 TIA), 3 MIs, and one death. Of 20 patients persistently anti-β2 GPI positive and either persistently aPS or aCL positive, there were 5 TOEs: 1 stroke, 2 TIA, and 2 MIs.

There were no single aPLs nor any persistently positive aPLs associated with the occurrence of TOE/death. Persistently positive anti-β2 GPI (on any 2 assays performance consecutively of the 3 time points combined with positive on all 3 assays) showed a trend (adjusted OR 2.09, 95% CI 0.94–4.65, p = 0.07). Positive on any 1 aPS measurement and aCL conferred an increased risk of TOE/death over being positive on zero measurements. However, positive on 2 or 3 aCL measurements conferred a decreased risk over zero positive measurements. Increasing numbers of positive anti-β2 GPI were not associated with either increased or decreased risk of TOE/death (table 3). There was no significant difference between IgG and IgM isoforms for recurrence risk for any of the 3 aPLs. There were too few high positive titers of any aPL for analyses. Table 4 shows the frequency of subjects who had positive aPL at baseline and negative at follow-up.

### Table 2. Percent positivity of aPL at each time period

<table>
<thead>
<tr>
<th>aPL assay</th>
<th>Baseline</th>
<th>Month 12</th>
<th>Month 24</th>
<th>p value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>β2GPI</td>
<td>9</td>
<td>7</td>
<td>9</td>
<td>0.49</td>
</tr>
<tr>
<td>aPS</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>0.98</td>
</tr>
<tr>
<td>aCL</td>
<td>28</td>
<td>37</td>
<td>29</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* Difference between visits (chi-square test).

### Table 3. Association between TOE and number of positive assays adjusted for baseline factors

<table>
<thead>
<tr>
<th>aPL assay</th>
<th>OR</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-β2GPI*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One positive vs. zero</td>
<td>1.05</td>
<td>0.63–1.77</td>
<td>0.84</td>
</tr>
<tr>
<td>Two positive vs. zero</td>
<td>1.02</td>
<td>0.44–2.34</td>
<td>0.97</td>
</tr>
<tr>
<td>Three positive vs. zero</td>
<td>0.77</td>
<td>0.29–2.03</td>
<td>0.59</td>
</tr>
<tr>
<td>Sedentary lifestyle</td>
<td>1.43</td>
<td>1.13–1.81</td>
<td>0.003</td>
</tr>
<tr>
<td>aPS†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One positive vs. zero</td>
<td>2.28</td>
<td>1.18–4.41</td>
<td>0.015</td>
</tr>
<tr>
<td>Two positive vs. zero</td>
<td>1.22</td>
<td>0.51–2.91</td>
<td>0.65</td>
</tr>
<tr>
<td>Three positive vs. zero</td>
<td>0.27</td>
<td>0.06–1.26</td>
<td>0.1</td>
</tr>
<tr>
<td>Sedentary lifestyle</td>
<td>1.41</td>
<td>1.12–1.79</td>
<td>0.004</td>
</tr>
<tr>
<td>aCL‡</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One positive vs. zero</td>
<td>1.81</td>
<td>1.38–2.37</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Two positive vs. zero</td>
<td>0.67</td>
<td>0.45–0.98</td>
<td>0.04</td>
</tr>
<tr>
<td>Three positive vs. zero</td>
<td>0.87</td>
<td>0.33–0.97</td>
<td>0.04</td>
</tr>
<tr>
<td>Medicaid</td>
<td>1.49</td>
<td>1.13–1.96</td>
<td>0.004</td>
</tr>
</tbody>
</table>

* Baseline variables included in model: history of coagulation, marital status, heavy alcohol use, moderate alcohol use, sedentary lifestyle, Caucasian ethnicity, diastolic hypertension.
† Age, history of coagulation, marital status, heavy alcohol use, moderate alcohol use, sedentary lifestyle, Caucasian ethnicity, diastolic hypertension.
‡ Age, Medicaid, heavy smoking, Caucasian ethnicity, male gender, systolic hypertension.

### Table 4. Frequency of positive aPL at baseline and negative at follow-up

<table>
<thead>
<tr>
<th>aPL assay</th>
<th>Positive at baseline</th>
<th>Negative at M12</th>
<th>Negative at M24</th>
</tr>
</thead>
<tbody>
<tr>
<td>aCL</td>
<td>279</td>
<td>123</td>
<td>105</td>
</tr>
<tr>
<td>Anti-β2</td>
<td>49</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>aPS</td>
<td>45</td>
<td>14</td>
<td>8</td>
</tr>
</tbody>
</table>

M12 = Month 12 of follow-up; M24 = month 24 of follow-up.

No subjects negative at baseline became positive at both months 12 and 24. For aPS, 36 of 115 (31.3%) demonstrated persistence while 20 of 115 (17.4%) were transiently positive. One patient missing aPS baseline was positive at both follow-ups. One subject who was aPS negative at baseline became positive at both follow-ups.

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Persistent anti-β2 GPI decreased the time to TOE (adjusted hazards ratio (HR) 2.86, 95% CI 1.21–6.76, p = 0.02). With a second persistent aPL (aCL or aPS), the HR increased to 3.79 (95% CI 1.18–12.14, p = 0.025). Otherwise, there were no single aPL, no persistent aPL and no combinations of aPL that decreased time to TOE (fig. 1 and 2).

Patients with TOE/death were more likely to have missing 12- and 24-month aPL measurements (p <
However, our sensitivity analysis found that baseline anti-β2 GPI positive did not correlate with missing aPL assays at 12 or 24 months (p > 0.5). Kappa scores did not correlate between positivity for anti-β2 GPI, aPS or aCL (kappas all <0.3). However, Pearson correlation coefficients of individual aPL assay titers over individual time points (from baseline to 12 to 24 months) ranged from 0.66 to 0.81.

**Discussion**

We were unable to demonstrate consistent positive relationships between any aPL positivity, persistent or otherwise, and TOE/death rate over 2 years post index stroke. While one positive titer showed an increased risk when compared to zero titers for both aPS and aCL, having more than one positive titer for aCL was actually associated with an unexpected decreased risk of TOE or death. One possible explanation is that aCL may not be as specific for risk of TOE as other aPLs [31]. It may also be explained by the average age and stroke risk factor prevalence of the cohort – 39 of 1,624 tested for anti-β2 GPI (2.4%) – but of those testing positive at baseline with follow-up testing, the percentage was considerably higher – 38 of 62 (61.3%). Reasons for TOE events occurring earlier without an increased rate are uncertain and may reflect small numbers among other reasons. The phenomenon may be analogous to the modulating effect of corticosteroids on exacerbations of multiple sclerosis – it gets the patient back to baseline quicker without any overall change in functional status.

Baseline anti-β2 GPI+ did not predict whether or not a patient would have missed their 12- or 24-month follow-up appointment but the presence of the clinical trial (WARSS) end point of stroke/death did predict missing follow-up data. This is most likely because the missing follow-up data at 12 or 24 months are consequences of dropping out due to the occurrence of a WARSS primary end point of stroke/death, given that there were no differences in TOE at baseline in any of the assays. The absence of an aPL assay performed does not necessarily mean that that assay is positive or more likely to be positive than

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Persistent aPL were more associated with thrombotic events in children with systemic lupus erythematosus than transient aPL, although transient LA and transient anti-β2GPI remained associated [26]. However, in a relatively small cohort of 34 children with first stroke/TIA, persistent IgG aCL did not predict recurrent TOE over a 2.8-year median follow-up [34]. Using binary partition evaluation, no titer criteria for aCL positivity (range 0–60 GPL units) predicted recurrent events.

Persistent aPL independently predicted recurrent stroke in a large, young (age 18–45 years, mean 36), Italian stroke cohort [11] followed prospectively for a median of 42 months, that is, 18 months longer than our cohort. Persistent aPL may confer a greater risk because of a longer exposure time. In 194 consecutive patients (with or without prior TOE) followed prospectively, persistent IgG anti-β2GPI was an independent risk factor for recurrent TOE [3]. A recent case–control study failed to demonstrate increase risk of adverse pregnancy outcomes due to persistent aCL [35]. Persistence of multiple, but not single aPL, may increase thrombosis risk in asymptomatic individuals, particularly with underlying autoimmune diseases [36].

Recent guidelines recommend that aPL detected acutely should persist to diagnose the antiphospholipid syndrome [31]. The revised Sapporo criteria for antiphospholipid syndrome calls for 12 weeks between assays (level C evidence), to increase specificity without sacrificing sensitivity [31]. The optimal waiting time remains unclear.

In a small, retrospective study [37], patients positive on more than one aPL had higher TOE rates, although aPL persistence was not studied. Identifying those patients at higher risk for earlier recurrent thrombosis could help direct treatment [38–41].

Based on the APASS-WARSS study [10], the most recent guidelines for the secondary prevention of aPL-associated, non-cardioembolic stroke recommend anti-platelets [42, 43]. However, as the initial APASS-WARSS study only looked at one-time aPL, some continue to treat patients with stroke fulfilling criteria for antiphospholipid syndrome with anticoagulation [44]. It is not possible to differentiate treatment effects (warfarin vs. aspirin) in this study, as group sizes are too small and underpowered.

Strengths of our study include prospective design and the relatively large stroke cohort studied serially for aPL (largest sample to date), independent blinded assessments of TOE and aPL status, a single, expert aPL research laboratory with over 20 years of experience, and standardized therapy arms [45].

Our study has limitations. A number of subjects were not tested at follow-up. The 257 APASS subjects with a primary end point in WARSS (recurrent stroke or death) would not have further follow-up. Other missing aPL are attributable to uncollected samples, unusable samples and insufficient quantity of serum. Despite these reasons, typically occurring randomly, the missing data are not biased with respect to baseline anti-β2GPI positivity, as demonstrated by the missing-at-random analysis. Furthermore, this is still the largest prospective study to date for determining the significance of persistent aPL after stroke.

Another potential limitation is that samples were stored for several years; however, many important prospective studies in this field used previously unthawed sera stored for several to many years [46], even decades longer than our study. We used only previously unthawed sera, minimizing this potential problem. Also, the definition of persistence of aPL was based on only 3 aPL determinations over 2 years and the follow-up period could have been too short to detect TOEs. We did not collect data on the presence of specific autoimmune diseases (e.g. SLE) in the cohort. A major limitation was that LA had not been tested in the follow-up of this study (to avoid potential unblinding of treatment arm). The population in WARSS [28] may not represent those likely to have a stroke from persistent aPL. Median age was 63 years, and due to exclusion criteria, there were a much larger proportion of small vessel strokes than seen generally. Conversely, there was a smaller proportion of large vessel strokes and no proven cardioembolic strokes. In daily clinical practice, physicians should not think of aPL as a main cause of stroke in this subset of patients. In fact, other vascular risk factors such as tobacco and hypertension were present in more than 60% of patients, diabetes mellitus in 30% and sedentary lifestyle in 40%. Assessing a younger group of aPL persistently positive patients with stroke/TIA who have relatively lower chances of having other risk factors is necessary. One study failed to show a difference in aPL between patients with cryptogenic and strokes of known etiology [47]. Another study found demographic characteristics, other risk factors, history of prior thromb-
Thrombotic events and distribution of etiopathogenic types of cerebral ischemia to not differ in young patients with or without aPL suggesting that with the exception of a clinical context of antiphospholipid syndrome or other autoimmune diseases, the usefulness of aPL in the management of cerebral ischemia remains limited [48].

Our results, taken together, appear to conform to the known paradoxical observations when studying recurrent risk — that thrombophilia, while predisposing to a first episode of deep vein thrombosis, does not increase the risk for recurrence [49]. This may be due to index event bias [50] based on selection of subjects who had a first event. As risk factors for index and recurrent events are often similar, there is a biasing of studies toward the null resulting in risk factor contributions to be substantially underestimated or reversed. This is also seen in the relationship between patent foramen and cryptogenic stroke [50].

In conclusion, our study suggests that persistent aPL may be a marker for increased risk for an earlier TOE/death. We failed to find increased TOE risk with persistent or multiple positive aPL.

Appendix: Co-Investigators at Participating APASS Centers

Louis R. Caplan, Beth Israel and New England Medical Center; Carlos S. Kase, Boston University; Patrick Pullicino, Buffalo General Hospital; Cathy Sila, Cleveland Clinic; Ralph L. Sacco, Columbia University; Constance Johnson, Johns Hopkins University; Fenwick Nichols, Medical College of Georgia; Cathryn Helgason, University of Illinois; Harold P. Adams Jr, University of Iowa; L. Creed Pettigrew, University of Kentucky; Percy Karanjia, Marshfield Clinic; J. Philip Kistler, Massachusetts General Hospital; Stanley Tuhrim, Mount Sinai School of Medicine; Gary Friday, Lankenau Medical Center; Joshua Hollander (deceased), Rochester General Hospital; Glen Fischberg, University of Southern California; Gregory W. Albers, Stanford University; Antonio Culebras, SUNY-Syracuse; James C. Grotta, University of Texas; Jonathan Dissin, Albert Einstein/PA and University of Vermont; E. Clarke Haley Jr, University of Virginia; Lawrence M. Brass (deceased), Yale University; David Anderson, Hennepin County Hospital; Richard Libman, Long Island Jewish Medical Center; Aaron Miller, Maimonides Medical Center; Anne N. Nafziger, Bassett Hospital; Jose Biller, Indiana University; Alejandro Forteza, University of Miami; Howard Kirshner, Vanderbilt University; Panayiotis Mitsias, Henry Ford Hospital; Mohammed Yaseen, Georgetown University; Dara Jamieson, Pennsylvania Hospital; B.K. Dandapani, Cleveland Clinic – FL; Laura Lennihan, Helen Hayes Hospital; Christy Jackson, UCSF; Seemant Chaturvedi, Wayne State University; John Rothrock, University of Southern Alabama; James Frey, Barrow Neurological Institute/St. Joseph’s Phoenix.

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Disclosure Statement


References

Antiphospholipid syndrome (APS) is characterized by the presence of autoantibodies to beta(2)-glycoprotein I (β2-GPI) and/or other phospholipids, often accompanied by thrombotic events. These autoantibodies are involved in the development of thrombi and can also cause miscarriages and other obstetric complications. The risk of thrombosis, miscarriages, and other complications is associated with the presence of specific antibody subtypes.

The risk of thrombosis in APS is influenced by various factors, including the presence of specific autoantibodies to β2-GPI, the clinical features of the disease, and the patient's co-morbidities. The risk of thrombosis can be assessed using standardized tests, such as the lupus anticoagulant (LA) test, anticardiolipin antibodies (aCL), and anti-β2-GPI antibodies.

Several studies have investigated the association between different types of antiphospholipid antibodies and the risk of thrombosis. For instance, the presence of anticardiolipin antibodies has been associated with an increased risk of thrombosis and pregnancy loss. Similarly, anti-β2-GPI antibodies have been linked to an increased risk of thrombosis and other complications.

Moreover, the presence of specific antibody subtypes, such as those reactive with domain 1 of β2-GPI, has been associated with a higher risk of thrombosis. These subtypes may have different clinical implications, and their detection may be important for risk stratification and management.

In summary, the presence of antiphospholipid antibodies, particularly specific subtypes, can increase the risk of thrombosis and other complications in APS. Therefore, it is essential to monitor and manage these autoantibodies to prevent or minimize the risk of complications.