2023 ACR/EULAR antiphospholipid syndrome classification criteria

Medha Barbhaiya ,[1] Stephane Zuily ,[2] Ray Naden,[3] Alison Hendry,[4] Florian Manneville,[5] Mary-Carmen Amigo,[6] Zahir Amoura,[7] Danieli Andrade ,[8] Laura Andreoli ,[9] Bahar Artim-Esen,[10] Tatsuya Atsumi,[11] Tadej Avcin,[12] Michael H Belmont ,[13] Maria Laura Bertolaccini,[14] D Ware Branch,[15] Graziela Carvalheiras,[16] Alessandro Casini,[17] Ricard Cervera,[18] Hannah Cohen,[19] Nathalie Costedoat-Chalumeau ,[20] Mark Crowther,[21] Guilherme de Jesús ,[22] Aurelien Delluc,[23] Sheetal Desai,[24] Maria De Sancho,[25] Katrien M Devreese,[26,27] Reyhan Diz-Kucukkaya,[28] Ali Duarte-García ,[29] Camille Frances,[30] David Garcia,[31] Jean-Christophe Gris ,[32] Natasha Jordan,[33] Rebecca K Leaf,[34] Nina Kello ,[35] Jason S Knight ,[36] Carl Laskin,[37] Alfred I Lee,[38] Kimberly Legault,[39] Steve R Levine,[40] Roger A Levy ,[41,42] Maarten Limper,[43] Michael D Lockshin,[1] Karoline Mayer-Pickel,[44] Jack Musial,[45] Pier Luigi Meroni ,[46] Giovanni Orsolini ,[47] Thomas L Ortel,[48] Vittorio Pengo ,[49] Michelle Petri ,[50] Guillermo Pons-Estel ,[51] Jose A Gomez-Puerta,[52] Quentin Raimboug,[53] Robert Roubey,[54] Giovanni Sanna,[55] Surya V Seshan,[56] Savino Sciascia ,[57,58] Maria G Tektonidou ,[59] Angela Tincani,[9] Denis Wahl,[2] Rohan Willis,[60] Cécile Yelnik,[61] Catherine Zuily,[62] Francis Guillemin,[5] Karen Costenbader ,[63] Doruk Erkan ,[1] on Behalf of the ACR/EULAR APS Classification Criteria Collaborators

ABSTRACT

Objective To develop new antiphospholipid syndrome (APS) classification criteria with high specificity for use in observational studies and trials, jointly supported by the American College of Rheumatology (ACR) and EULAR.

Methods This international multidisciplinary initiative included four phases: (1) Phase I, criteria generation by surveys and literature review; (2) Phase II, criteria reduction by modified Delphi and nominal group technique exercises; (3) Phase III, criteria definition, further reduction with the guidance of real-world patient scenarios, and weighting via consensus-based multicriteria decision analysis, and threshold identification; and (4) Phase IV, validation using independent adjudicators' consensus as the gold standard.

Results The 2023 ACR/EULAR APS classification criteria include an entry criterion of at least one positive antiphospholipid antibody (aPL) test within 3 years of identification of an aPL-associated clinical criterion, followed by additive weighted criteria (score range 1–7 points each) clustered into six clinical domains (macrovascular venous thromboembolism, macrovascular arterial thrombosis, microvascular, obstetric, cardiac valve, and hematologic) and two laboratory domains (lupus anticoagulant functional coagulation assays, and solid-phase enzyme-linked immunosorbent assays for IgG/IgM anticardiolipin and/or IgG/IgM anti–β_2-glycoprotein I antibodies). Patients accumulating at least three points each from the clinical and laboratory domains are classified as having APS. In the validation cohort, the new APS criteria vs the 2006 revised Sapporo classification criteria had a specificity of 99% vs 86%, and a sensitivity of 84% vs 99%.

Conclusion These new ACR/EULAR APS classification criteria were developed using rigorous methodology with multidisciplinary international input. Hierarchically clustered, weighted, and risk-stratified criteria reflect the current thinking about APS, providing high specificity and a strong foundation for future APS research.

INTRODUCTION

Antiphospholipid syndrome (APS) is a systemic autoimmune disease characterised by arterial, venous, or microvascular thrombosis, pregnancy morbidity, or nonthrombotic manifestations in patients with persistent antiphospholipid antibodies (aPL). Classification of APS, for the identification of homogeneous research cohorts, is currently based on the Sapporo criteria published in 1999[1] and revised in 2006.[2] The revised Sapporo criteria for APS require clinical features (thrombosis or pregnancy morbidity) and laboratory tests (for lupus anticoagulant (LAC), IgG/IgM anticardiolipin antibodies (aCL), and/or IgG/IgM anti–β_2-glycoprotein I antibodies [anti-β_2GPI]) with at least 2 aPL tests performed at least 12 weeks apart.[2]

Since the introduction of the Sapporo criteria, advancements in our understanding of APS include better characterisation of aPL-associated nonthrombotic clinical manifestations, identification of the role of traditional thrombosis risk

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For numbered affiliations see end of article.

Correspondence to
Dr Doruk Erkan, Rheumatology, Hospital for Special Surgery, New York, NY 10021, USA; erkand@hss.edu

RN is deceased

MB and SZ contributed equally.

MB and SZ are joint first authors.

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factors in aPL-positive individuals, and risk stratification by aPL profile.[3 4] Furthermore, the revised Sapporo criteria have been criticised for not incorporating evidence-based definitions, e.g., aPL positivity, microvascular disease, or pregnancy morbidity, resulting in the inclusion of a heterogeneous group of "aPL-positive" patients with different risk profiles for research.[4 5] More stringent methodology, using data-driven and expert-based approaches to develop robust classification criteria in rheumatic diseases, is now available.[6] Thus, new classification criteria can better ensure future high-quality, risk-stratified epidemiologic studies and clinical trials in APS, leading to improved patient care and management recommendations.

Given the limitations of the current criteria,[7–9] an international effort, jointly supported by the American College of Rheumatology (ACR) and EULAR, was initiated with the goal of using rigorous methodology to develop a new APS classification system based on a more modern disease understanding, allowing for the weighting of individual criterion, and demonstrating excellent operating characteristics with the highest possible specificity. Maximising the specificity of the 2023 ACR/EULAR APS classification criteria was a major goal at the outset, as overly inclusive criteria may decrease the ability of investigators to understand disease pathophysiology and treatment effects in clinical trials and research.

METHODS

Methodologic overview

Our 4-phase methodology (see online supplemental section 1) was similar to the methodologies used in the development of recent rheumatic disease classification criteria.[10–16] The phases were as follows: Phase I, criteria generation; Phase II, criteria reduction; Phase III, criteria definition, further reduction, and weighting through a consensus-based multicriteria decision analysis (MCDA) methodology,[17–19] as well as classification threshold identification; and Phase IV, validation.

The initiative was overseen by a 24-member international multidisciplinary Steering Committee, led by principal investigators from North America (DE) and Europe (SZ); 13 members were from the Americas, 9 from Europe, and two from New Zealand. Steering Committee members were selected based on their expertise in APS and/or methodologies; 3 patients (US and Europe) represented the patient experience. The Steering Committee assembled (1) a core planning group; (2) a master group of 54 international physician-scientists designated as "Collaborators" (40% from Europe, 40% from North America, and 20% from South America, based on their clinical and/or research APS interest); and (3) domain-specific subcommittees. Members of these relevant Steering Committee groups are listed below in the collaborators section.

Phase I (criteria generation) and Phase II (criteria reduction) overview

In Phase I, we generated a comprehensive list of candidate criteria, using both consensus-based and evidence-based methods. We e-mailed a survey with open-ended questions to the master group (n=54) to identify potential criteria and different APS subpopulations. We systematically clustered responses by organ systems to avoid duplication and improve interpretability, and reviewed the literature for additional items.

In Phase II, we reduced the generated list using systematic reviews, meta-analyses,[20–24] and expert consensus. We administered two consecutive surveys (61 expanded master group members, 19 Steering Committee members) assessing the specificity of each Phase I item in differentiating APS from similar conditions. We ranked items by mean survey score, hierarchically organised them into domains by specificity, and eliminated low-specificity items by nominal group technique during an in-person meeting.[25 26] Within each domain, the Steering Committee agreed that only the highest specificity item should be scored, consistent with classification criteria methodology.[6] In addition, the Steering Committee discussed the need for "entry criteria," that is, minimum criteria required to identify the relevant patient population to whom the classification criteria would be applied (for further details on Phases I and II, see Barbhaiya *et al*[8]).

Phase III (criteria definition, further reduction, and weighting, and classification threshold identification) overview

In Phase III, we defined criteria generated during Phase I/II, as part of clinical (Phase III-A) and laboratory (Phase III-B) domains, further reduced the number of criteria using expert consensus and real-world patient scenarios (Phase III-C), and determined criteria weights and the threshold above which cases would be consistently classified as APS (Phase III-D). We also finalised the entry criteria. For details, see online supplemental section 3.

Phase IV (validation) overview

In Phase IV, using two separate validation cohorts, we compared performance characteristics of the revised Sapporo criteria to those of the new APS classification criteria against consensus by independent adjudicators, that is, representing the "gold standard." We made an a priori decision to have two validation cohorts, in order to demonstrate consistency and validity. We assembled cohorts by asking Phase IV Collaborators (selected among the original 54 members and 20 additional members, none of whom were involved in Phase III) to contribute 30 cases evaluated for "APS suspicion," that is, a clinical APS manifestation with any positive or negative aPL test result or no aPL test, or a positive aPL test result with no clinical APS manifestation. Of the 30 cases, half were considered "likely" and half "not likely" to be APS for research purposes. We collected clinical and laboratory data relevant to the revised Sapporo criteria and new classification criteria using a standardised form; cases were randomly assigned to two different cohorts.

APS classification for each case was verified by three independent adjudicators (a rheumatologist from North America (RR), an internist/clinical immunologist from Europe (ZA), and a haematologist from Europe (HC)), who were blinded with regard to the Phase III discussions and unaware of the proposed classification criteria. Adjudicators participated in a moderated discussion of discordant cases at the end of each validation cohort assessment until agreement was reached. Moderated discussions were aimed at focusing adjudicators on factors relevant for APS case classification, avoiding additional information to reduce bias.

Phase IV (validation) statistical analysis

Assuming a total discordance of 20%, that is, disagreement between expert consensus and new criteria, a power of 80%, and an alpha risk of 5%, an estimated sample size of 243 would be necessary to detect a difference in performance characteristics between the revised Sapporo and new APS classification criteria. We incorporated two validation cohorts (n=284 per cohort) in Phase IV. Sensitivity, specificity, and Wald 95% confidence intervals (95% CIs) for each validation cohort were comparatively

evaluated for the revised Sapporo and new APS classification criteria, each against independent adjudicators' consensus. Nonoverlapping CIs and a *P* value threshold of<0.05 denoted significance. For details, see online supplemental section 6.

Statistical analyses were performed using SAS version 9.4 (SAS Institute). This study was approved by the Hospital for Special Surgery Institutional Review Board, and by individual centres as needed.

RESULTS

Phase I (criteria generation) and phase II (criteria reduction)

Phase I generated 152 candidate criteria, expanded to 261 items with subgroups and candidate criteria with potential negative weights. Subsequent reduction methods resulted in 27 candidate criteria, hierarchically organised into six additive domains (macrovascular, microvascular, obstetric, cardiac valve, hematologic, and laboratory) (for details, see the Table in online supplemental section 2).

During an in-person meeting, the Steering Committee agreed that to maximise specificity, candidate clinical criteria must be interpreted in the context of a "clinically acceptable" aPL profile, emphasising the importance of "entry criteria." Following this meeting, modified Delphi exercises were carried out, as follows: (1) all members voted in favour of entry criteria requiring at least 1 clinical and one laboratory criterion; and (2) the majority voted in favour of a time restriction between the clinical and laboratory criterion as part of the entry criteria.[8]

Phase III (criteria definition, further reduction, and weighting, and classification threshold identification)

Phase III-A, clinical definitions

The Steering Committee developed clinical candidate definitions (Phase III-A) for the following features: (1) macrovascular thrombosis and traditional venous thromboembolism (VTE) and cardiovascular disease (CVD) risk factors (see online supplemental section 8); (2) microvascular disease; (3) pregnancy morbidity; (4) cardiac valve involvement; and (5) thrombocytopenia (tables 1 and 2) (details will be published elsewhere).[27]

Phase III-B, laboratory definitions

The Steering Committee agreed on the following criteria for laboratory items (Phase III-B): (1) International Society on Thrombosis and Haemostasis (ISTH) guidelines should be followed for LAC testing and interpretation (table 1)[27]; and (2) single (one-time) LAC positivity may be relevant when repeat testing is unavailable. Pending assessment and refinement during the subsequent Phase III-C, the Steering Committee recommended that (1) there should be 2 levels of aCL/anti-β_2GPI positivity ("moderate" and "high" positivity) based on enzyme-linked immunoassay (ELISA) techniques; (2) IgG aCL and IgG anti-β_2GPI positivity should be evaluated in combination; and (3) IgG and IgM isotypes should not be additively considered (details will be published elsewhere).

Finally, given the limited data for or against the definition of aPL "persistence" (ie, 2 positive tests for aPL at least 12 weeks apart),[1 2 28] the Steering Committee decided not to change the definition.

Phase III-C, finalisation of the entry criteria

The Steering Committee agreed that an entry criteria time restriction of 3 years (vs 5 years in the revised Sapporo criteria) between a clinical criterion and a positive aPL test result improves certainty for APS classification; however, this decision was based on limited data[29] and on primarily Steering Committee consensus (modified Delphi exercise). The final entry criteria, requiring the presence of at least one clinical criterion and one laboratory criterion (positivity for LAC, moderate- or high-level IgG/IgM aCL positivity, or moderate- or high-level IgG/IgM anti-β_2GPI positivity) within 3 years of each other, are presented in figure 1.

Phase III-C, real-world case collection and analysis

Of 314 potential APS cases in the derivation cohort (mean±SD age 44.7±14.6 years; 79% female) collected from 17 sites, including eight from Europe (47%), 7 from North America (41%), and two from South America (12%), case collectors rated 137 cases (44%) as "highly likely" and 177 cases (56%) as "equivocal or unlikely" to be APS. Duration between aPL positivity and any candidate clinical criteria was≤3 years in 89% of cases.[30]

Phase III-C, consensus discussions for further criteria reduction and final definitions

Discussions and decisions based on derivation cohort results, literature review, and expert consensus are summarised in online supplemental section 5. Eventually, the definitions and hierarchical order of items within each of 8 additive and independent domains (six clinical, 2 laboratory) were finalised (table 3). The Steering Committee also concluded that (1) patients with concomitant systemic autoimmune disease could be classified as having APS, but individual candidate criterion should not be scored if other "equally likely" or "more likely" causes for that criterion cannot be excluded, similar to other criteria sets[12]; (2) "persistent" aPL should be scored based on two consecutive results; and (3) "moderate" level aCL/anti-β_2GPI positivity should be defined as 40–79 ELISA units and "high" level as≥80 ELISA units.

Phase III-D, criteria weighting based on MCDA and classification threshold identification

During the in-person meeting, the MCDA exercise calculated weights based on 81 pairwise consensus-based decisions. Table 3 shows the resulting point-based classification system, with hierarchical levels in each domain identified based on their relative weights.

Following the in-person meeting, the minimum classification threshold was determined based on individual assessment of the 192 unique derivation cohort cases remaining after eliminating duplicates and cases not meeting the entry criteria. Of 192 cases, full agreement with APS classification was achieved for 116 cases (60%) (90 classified as APS, 26 as not APS). Agreement was relatively high for 37 cases (19%), with 80–93% agreeing with the classification (17 as APS, 20 as not APS). However, there were variable responses (50–80%) for the remaining 39 cases (20%).

Within each domain, descriptive analysis of the 192 cases showed that most respondents considered that 1) the presence of 1 "B" level clinical criterion, even with "C" or higher-level laboratory criteria, was insufficient for APS classification, but two or more "B" level (and/or one or more "C" or higher-level) clinical criteria were acceptable; and 2) the presence of 1 or 2 "B" level laboratory criteria, even with "C" or higher-level clinical criteria, was insufficient for APS classification (table 3).

During several teleconferences, all cases without 100% agreement were discussed with the guidance of the descriptive analysis until full consensus was achieved. Key conceptual issues addressed included the following: (1) the need to emphasise specificity over sensitivity to improve homogeneity of APS patients in

Table 1 Definitions of the 2023 ACR/EULAR antiphospholipid syndrome (APS) classification criteria

Clinical criteria
Domain 1 — Macrovascular (venous thromboembolism)
Venous thromboembolism (otherwise unexplained* and confirmed by appropriate testing): Includes (but is not limited to) pulmonary embolism, deep vein thrombosis of the legs/arms, splanchnic thrombosis, renal vein thrombosis, cerebral venous thrombosis, and retinal vein thrombosis/occlusion.
Domain 2 — Macrovascular (arterial thrombosis)
Arterial thrombosis (otherwise unexplained* and confirmed by appropriate testing): Includes (but is not limited to) myocardial infarction (coronary artery thrombosis), peripheral/splanchnic/retinal artery thromboses, stroke based on international definitions,[35 36] and other organ infarcts (eg, kidney, liver, or spleen) in the absence of visualised thrombus.
Domain 3 — Microvascular
Suspected:
Livedo racemosa (by physical examination): Otherwise unexplained* violaceous, "net-like," blotchy mottling of the skin. Note: livedo racemosa with nonuniform, irreversible, broken, and asymmetric persistent discoloration should be scored; *livedo reticularis with uniform, reversible, unbroken, and symmetric discoloration should* not *be scored*.
Livedoid vasculopathy lesions (by physical examination): Otherwise unexplained* painful papules and erythematous-violaceous purpuric plaques, which may rapidly evolve into haemorrhagic vesicles or bullae. Note: if ruptured, can result in painful small ulcers or reticulate, confluent, geometric, and painful ulcers.
Antiphospholipid antibody (aPL) nephropathy (by physical examination or laboratory tests): Otherwise unexplained persistent: (a) new-onset hypertension or deterioration of previously well-controlled hypertension; (b) proteinuria≥0.5 gm in 24-hour urine specimen or protein:creatinine ratio ≥0.5 mg/mg (50 mg/mmoles); (c) acute renal failure (increased serum creatinine levels above normal); or (d) glomerular microscopic hematuria.
Pulmonary hemorrhage (by clinical symptoms and imaging): Respiratory symptoms (eg, dyspnoea, cough, hemoptysis) AND otherwise unexplained* pulmonary infiltrates on imaging suggestive of pulmonary hemorrhage.
Established:
Livedoid vasculopathy (by pathology once livedoid vasculopathy lesions described above are present**)**: Otherwise unexplained thrombosis of the small dermal vessels and/or endothelial proliferation.
aPL nephropathy (by pathology once suspected aPL-nephropathy definition above is fulfilled**)**[37]: (a) **Acute renal vascular or glomerular thrombotic microangiopathy lesions**, including fibrin thrombi in arterioles or glomeruli without inflammatory cells or immune complexes; and (b) **chronic renal vascular or glomerular lesions**, described as arterial or arteriolar organised microthrombi with or without recanalisation, fibrous and fibrocellular (arterial or arteriolar) occlusions, focal cortical atrophy with or without thyroidization, fibrous intimal hyperplasia, or chronic/organised glomerular thrombi. Note: in patients with systemic lupus erythematosus, aPL nephropathy occurs independent of lesions attributable to lupus nephritis.
Pulmonary hemorrhage (by bronchoalveolar lavage [BAL] or pathology once suspected pulmonary hemorrhage definition above is fulfilled**)**: Otherwise unexplained* progressive haemorrhagic return on BAL with aliquots or hemosiderin-laden macrophages (>20%), OR lung biopsy demonstrating capillaritis or microthrombosis.
Myocardial disease (by imaging or pathology): Otherwise unexplained* non-ST segment elevation myocardial infarction with a normal coronary angiogram (myocardial infarction with nonobstructive coronary arteries, or MINOCA) AND cardiac magnetic resonance imaging (CMRI) abnormalities as per the 2018 Society for CMRI expert consensus[38] including: (a) late gadolinium enhancement either transmurally or subendocardially; (b) T2 abnormalities (weighted imaging or mapping); or (c) perfusion MRI abnormalities, OR histologically by thrombosis of the small vessels of the heart.
Adrenal hemorrhage or microthrombosis (by imaging or pathology): Otherwise unexplained* CT or MRI demonstrating hemorrhage, OR histologically by thrombosis of the adrenal (micro)vasculature, for example, adrenal plexus, adrenal vein.
Domain 4 — Obstetric
Prefetal death (preembryonic or embryonic loss): Otherwise unexplained* pregnancy loss before 10 weeks 0 days of gestation.
Fetal death: Otherwise unexplained* pregnancy loss between 10 weeks 0 days and 15 weeks 6 days gestation (early fetal death), or between 16 weeks 0 days and 34 weeks 0 days gestation. Note: if a detailed analysis of the fetal morphology or genetic constitution is not performed or unavailable, reasonable clinical judgeoccasions at least 4 hours hours apartment should be used based on careful history and review of available medical records.
Preeclampsia with severe features:[39] **Preeclampsia** defined as a systolic blood pressure≥140 mm Hg or diastolic blood pressure≥90 mm Hg on 2 occasions at least 4 hours apart after 20 weeks of gestation in a previously normotensive or hypertensive (chronic†) patient AND new onset of one or more of the following: (a) proteinuria ≥0.3 mg/mg (30 mg/mmoles) in a random urine specimen or (b) dipstick protein ≥2+ if a quantitative measurement is unavailable AND one or more of the following "severe features":
Severe blood pressure elevation: Systolic blood pressure≥160 mm Hg or diastolic blood pressure≥110 mm Hg on 2 occasions at least 4 hours apart while the patient is on bed rest (antihypertensive therapy may be initiated on confirmation of severe hypertension, in which case severe blood pressure elevation criteria can be satisfied without waiting until 4 hours have elapsed).
Central nervous system dysfunction: New-onset headache unresponsive to medication and not accounted for by alternative diagnosis.
Visual disturbances.
Pulmonary oedema.
Impaired liver function: Abnormally elevated blood concentrations of liver enzymes (more than twice the upper limit of normal concentrations), or severe persistent right upper quadrant or epigastric pain unresponsive to medications, not accounted by alternative diagnosis.
Renal dysfunction: Serum creatinine concentration >1.1 mg/dL or a doubling of the serum creatinine concentration in the absence of other renal disease.
Thrombocytopenia: platelet count of $<100 \times 10^9$/liter.
Placental insufficiency with severe features: **Intrauterine fetal growth restriction** defined as biometry indicating estimated fetal weight of less than the 10th percentile for gestational age or postnatal birth weight less than the 10th percentile for gestational age in the absence of fetal-neonatal syndromes or genetic conditions associated with growth restriction AND one or more of the following "severe features":
Abnormal or non-reassuring fetal surveillance test(s) suggestive of fetal hypoxemia, e.g., a nonreactive non-stress test
Abnormal Doppler flow velocimetry waveform analysis suggestive of fetal hypoxemia, e.g., absent end-diastolic flow in the umbilical artery.
Severe intrauterine fetal growth restriction suggested by fetal biometry indicating an estimated fetal or postnatal birth weight of<3 rd percentile for gestational age.
Oligohydramnios, e.g., an amniotic fluid index≤5 cm, or deepest vertical pocket<2 cm.

Continued

Table 1 Continued

Clinical criteria
Maternal vascular malperfusion on placental histology suggested by placental thrombosis/infarction, inadequate remodelling of the uterine spiral arteries (decidual vasculopathy), decreased vasculosyncytial membranes, increased syncytial knots, or decidual inflammation.[40] Note: Maternal vascular malperfusion on placental histology can be detected in the placentas of aPL-negative patients with intrauterine growthrestriction and/or preeclampsia, and even in normal pregnancies; thus, these findings are not specific for APS.
Domain 5 – Cardiac valve
Valve thickening (otherwise unexplained*): Based on World Heart Federation echocardiographic criteria,[41] mitral valve thickening is defined as>4 mm between ages 20–39 years and>5 mm for those older than age 40 years, and>3 mm for other valves for any age (valve thickening can be associated with valvular dysfunction (regurgitation or stenosis)).
Valve vegetation (otherwise unexplained*): Based on the American Society of Echocardiography guidelines,[42] valve vegetation is defined as shaggy, lobulated, or rounded masses typically located on the atrial side of atrioventricular valves (mitral valve and tricuspid valve) or ventricular side of the aortic valve, but can be located on any side of any valve (size is highly variable but usually <1 cm); on echocardiogram, despite the "echo texture" and location of aPL-associated vegetations resembling infective endocarditis, they may appear less amorphous, more rounded, and not associated with valvular destruction, in contrast to a true infective endocarditis; they can be associated with valvular dysfunction (regurgitation or stenosis).
Domain 6 – Haematology
Thrombocytopenia: Otherwise unexplained* lowest platelet count ever between 20 and 130×10^9/liter, confirmed on peripheral blood smear and by repeat testing.
*Refer to online supplemental section 4 for the definition of "otherwise unexplained," which requires the exclusion of "equally likely" or "more likely" causes based on investigator's judgement. Clinical domain items with an "equally or more likely" cause should not be scored (note: venous thromboembolism and cardiovascular risk factors required for Domains 1 and 2 scoring are not reasons for exclusion). †Patients with chronic hypertension can be classified as having superimposed preeclampsia if there is a sudden increase in baseline hypertension and/or proteinuria after 20 weeks of gestation.
Laboratory Criteria
Domain 7 — aPL test by coagulation-based functional assay
Lupus anticoagulant (LAC) assay performed and interpreted based on the International Society of Thrombosis and Hemostasis (ISTH) guidelines[27], which can be summarised as follows:
A 3-step procedure (screening – mixing study – confirmation) with 2 screening test systems (diluted Russell's viper venom time and a sensitive activated partial thromboplastin time [low phospholipids and silica as activator]) is necessary to confirm the presence of LAC. The LAC test should be considered positive if at least 1 of the 2 test systems yields a positive result following all 3 steps (phospholipid-dependent correction of the prolonged screening tests).
Results of LAC testing should be interpreted with caution, as false positive and negative results can occur during anticoagulation (thus, LAC testing is ideally performed in patients not receiving anticoagulants), as an acute-phase response (eg, acute thrombosis) due to acute-phase reactants (eg, Factor VIII and C-reactive protein), and in pregnancy due to increase in blood coagulation factors.
Samples from patients receiving anticoagulants (vitamin K antagonists, heparin, direct oral anticoagulants, indirect Factor Xa inhibitor) should be marked positive or negative on the LAC assay only if reviewed/confirmed by an individual with expertise in performing/interpreting the LAC assay, for example, expert laboratory personnel.
Domain 8 — aPL test by solid phase–based assay
Anticardiolipin antibody (aCL) and anti–β_2-glycoprotein I antibody (anti-β_2GPI) thresholds of moderate (40–79 units) and high (≥80 units) should be determined based on standardised ELISA results, not based on other testing modalities such as new automated platforms with variations of the solid phase (eg, magnetic microparticles and microspheres) and various detection systems (eg, chemiluminescent immunoassay (CLIA), multiplex flow immunoassay (MFI), or flow cytometry).
Correlation of the numerical values between the moderate/high thresholds of ELISA and automated platforms varies substantially. For instance, based on the ISTH Scientific and Standardisation Committee (SSC) LA/aPL Subcommittee estimates from one study, an IgG aCL ELISA value of 40–79 units corresponds to a CLIA value of 200–400 units and MFI of 700–2000.[33] While these data may provide future guidance, there is currently no direct application and therefore, more validation studies are needed.
Recommendations to maintain homogeneity, consistency, and comparability of clinical research studies include the following: (a) results of analytical platforms should not be mixed; (b) pending additional studies and official guidance from the ISTH SSC LAC/aPL Subcommittee for semiquantitative comparisons on aCL/anti-β_2GPI moderate/high thresholds of ELISA and automated platforms, we recommend delaying use of the automated platforms for APS classification; and (c) if no options exist beside the use of automated platform results for APS research, researchers should direct efforts to identifying and validating moderate/high thresholds of their platform, correlating it with aCL/anti-β_2GPI ELISA moderate/high thresholds (these measures should be discussed in their methods, and supported by official guidance).

research and to avoid enrolling misclassified patients in clinical trials with potentially toxic investigational medications; and (2) structuring the classification system to include an acceptable clinical criterion and an acceptable aPL laboratory criterion. Relative weights derived from 1000Minds analysis supported these ranking exercises, with one exception: combined weights of the "B" level macrovascular (VTE) and obstetric domains were low; the Steering Committee agreed that the combination would not meet the threshold for an acceptable clinical profile. As a result, consensus for the preliminary threshold for APS classification was achieved.

Despite Steering Committee agreement on the "APS" threshold, detailed analysis of the 39 cases with variable responses demonstrated the most frequently encountered controversial scenarios. These scenarios were (1) moderate- or high-titre IgM aCL/anti-β_2GPI alone ("B" level) (table 3) with an acceptable clinical criterion (12 [31%] of 39 cases); (2) VTE or arterial thrombosis alone in patients with high-risk profiles for VTE or CVD ("B" level), with an acceptable laboratory criterion (9 [23%] of 39 cases); and (3) occurrence of 3 or more consecutive prefetal deaths (at<10 weeks) and/or early fetal deaths (at 10–16 weeks), or one or more fetal deaths (at≥16 weeks to<34 weeks) alone ("B" level) in the context of an acceptable laboratory criterion (8 [21%] of 39 cases).

The 2023 ACR/EULAR APS classification criteria are presented in figure 1. According to these criteria, patients should be classified as having APS if they fulfil the entry criteria (at least 1 clinical and one laboratory criterion within 3 years of each other) and accumulate at least three points from clinical domains and three points from laboratory domains.

Phase IV (validation)

We collected 568 potential APS cases from 29 international sites, including Europe (16 centers [55%]), North America (11 centers

Table 2 Definitions of high-risk venous thromboembolism (VTE) and cardiovascular disease (CVD) profiles based on current general population guidelines (refer to online supplemental section 8 for details)

1. **To determine if a thrombotic event occurred in a patient with a high-risk VTE or high-risk CVD profile**, investigators should make every effort to collect and review risk factor data based on patient report or medical record review. if clinically relevant VTE or CVD risk factors at the time of an historical thrombotic event are unknown in the data source, then the lowest possible non-zero weight should be assigned to the macrovascular event to avoid overestimation of antiphospholipid antibody (aPL) contribution to thrombosis.

2. **High-risk VTE profile is defined based on 1 or more major OR 2 or more minor VTE risk factors**, if timeline/severity is associated with the event based on investigator's judgement (timelines based on general population guidelines are provided when available).

a. **Major VTE risk factors** (any of the following at the time of the event):
   - Active malignancy with no or noncurative treatment received, ongoing curative treatment including hormonal therapy, or recurrence/progression despite curative treatment at the time of the event.
   - Hospital admission confined to bed (only bathroom privileges) with an acute illness for at least 3 days within 3 months prior to the event.
   - Major trauma with fractures or spinal cord injury within 1 month prior to the event.
   - Surgery with general/spinal/epidural anaesthesia for >30 min within 3 months prior to the event.

b. **Minor VTE risk factors** (2 or more of the following at the time of the event):
   - Active systemic autoimmune disease or active inflammatory bowel disease using disease activity measures guided by current recommendations.
   - Acute/active severe infection according to guidelines, for example, sepsis, pneumonia, SARS-CoV-2.
   - Central venous catheter in the same vascular bed.
   - Hormone replacement therapy, estrogen containing oral contraceptives, or ongoing in vitro fertilization treatment.
   - Long distance travel (≥8 hours).
   - Obesity (body mass index (BMI) ≥30 kg/m²)
   - Pregnancy or postpartum period within 6 weeks after delivery.
   - Prolonged immobilisation not counted above, for example, leg injury associated with reduced mobility, or confined to bed out of hospital for at least 3 days.
   - Surgery with general/spinal/epidural anesthesia for<30 min within 3 months prior to the event.

3. **High-risk CVD profile is defined based on 1 or more high CVD risk factors OR 3 or more moderate CVD risk factors**, if timeline/severity is associated with the event based on investigator's judgement (timelines based on general population guidelines are provided when available).

a. **High CVD risk factors** (any of the following at the time of the event):
   - **Arterial hypertension** with systolic blood pressure (BP) ≥180 mm Hg or diastolic BP ≥110 mm Hg.
   - **Chronic kidney disease** with estimated glomerular filtration rate≤60 mL/minute for more than 3 months.
   - **Diabetes mellitus** with organ damage* or long disease duration (type 1 for ≥20 years; type 2 for≥10 years).
   - **Hyperlipidemia** (severe) with total cholesterol ≥310 mg/dL (eight mmoles/litre) or low-density lipoprotein (LDL)–cholesterol>190 mg/dL (4.9 mmoles/litre).

b. **Moderate CVD risk factors** (3 or more of the following at the time of the event):
   - **Arterial hypertension** on treatment, or with persistent systolic BP≥140 mm Hg or diastolic BP≥90 mm Hg.
   - **Current tobacco smoking**.
   - **Diabetes mellitus** with no organ damage* and short disease duration (type 1<20 years; type 2<10 years).
   - **Hyperlipidemia** (moderate) on treatment, or with total cholesterol above normal range and <310 mg/dL (eight mmoles/litre), or LDL-cholesterol above normal range and<190 mg/dL (4.9 mmoles/litre).
   - **Obesity** (BMI≥30 kg/m²).

*Diabetes mellitus diagnosis based on a haemoglobin A1c≥6.5%, or a fasting plasma glucose≥126 mg/dL (7.0 mmoles/litres), or symptoms of diabetes (eg, polyuria, polydipsia, or unexplained weight loss) with a random plasma glucose concentration ≥200 mg/dL (11.1 mmoles/litre). According to the 2019 ESC/EASD guidelines on diabetes, organ damage is defined by proteinuria, chronic kidney disease, left ventricular hypertrophy, or retinopathy (see Cosentino *et al*[43]).

[38%]), South America (one center [3%]), and Asia (one center [3%]), to assess the performance characteristics of the preliminary classification criteria.

In the first validation cohort (n=284), independent adjudicators classified 98 cases (35%) as "APS" and 180 (63%) as "No APS." Six cases (2%) were excluded—one case was excluded due to unresolved disagreement on classification, and 5 cases were excluded due to being unclassifiable because of incomplete data.

Following assessment of the first cohort, assessment of the second validation cohort was carried out based on adjudicators' recommendations, as follows: (1) the definition of placental insufficiency was further characterised (table 1); and (2) each case was assessed using complete individual VTE/arterial thrombosis risk factor data, rather than the overall risk factor profile. In the second validation cohort (n=284), the adjudicators classified 113 cases (40%) as "APS" and 162 cases (57%) as "No APS"; 9 subjects (3%) were excluded as they were unclassifiable due to incomplete data.

Characteristics of the first validation cohort (n=278) and second validation cohort (n=275) are shown in table 4. Of the 553 patients, the age of the majority of them was 40 years or higher, and the cohort was predominantly White and female, consistent with APS demographics from other international cohorts.[31] For both validation cohorts, the operating characteristics of the 2023 ACR/EULAR APS classification criteria, using the independent adjudicators' consensus as the gold standard, demonstrated very high specificity of 99% in each cohort (95% CI 0.98 to 1.00 in cohort 1, and 95% CI 0.97 to 1.00 in cohort 2), whereas the revised Sapporo criteria for APS had a specificity of 91% (95% CI 0.86 to 0.95) in cohort 1 and 86% (95% CI 0.81 to 0.92) in cohort 2. The sensitivity of the new ACR/EULAR APS criteria was 83% (95% CI 0.75 to 0.90) in cohort 1 and 84% (95% CI 0.77 to 0.91) in cohort 2, compared with a sensitivity of 100% (95% CI 1.00 to 1.00) in cohort 1 and 99% (95% CI 0.98 to 1.00) in cohort two using the revised Sapporo criteria (table 5) (see online supplemental section 7 for further analysis).

DISCUSSION

The 2023 ACR/EULAR APS classification criteria comprise an additive, weighted system, assessing an individual's relative probability of APS and defining a threshold for APS classification for research purposes. The new criteria were developed in four rigorous phases under the guidance of international physician-scientists experienced in the evaluation and management of APS patients, while utilising international cohorts totaling approximately 900 patients spanning the spectrum of APS. The new criteria are a paradigm shift in APS classification, given that: (1) these carefully defined clinical and laboratory criteria, based on

Entry Criteria[a]
At least one documented[b] clinical criterion listed below (domains 1-6)
plus
A positive antiphospholipid antibody (aPL) test
(a lupus anticoagulant test, or moderate-to-high titers of anticardiolipin or anti-β_2-glycoprotein-I antibodies [IgG or IgM])
within three years[b] of the clinical criterion

If absent, do not attempt to classify as APS - If present, apply additive criteria

Additive clinical and laboratory criteria[a]
Do not count a clinical criterion if there is an equally or more likely explanation than APS.
Within each domain, only count the highest weighted criterion towards the total score.

Clinical domains and criteria	Weight	Clinical domains and criteria	Weight
D1. Macrovascular (Venous Thromboembolism [VTE])		**D2. Macrovascular (Arterial Thrombosis [AT])**	
VTE with a high-risk VTE profile[c]	1	AT with a high-risk CVD profile[c]	2
VTE without a high-risk VTE profile[c]	3	AT without a high-risk CVD profile[c]	4
D3. Microvascular		**D4. Obstetric**	
Suspected (one or more of the following)	2	≥3 Consecutive pre-fetal (<10w) and/or early fetal (10w 0d -15w 6d) deaths	1
Livedo racemosa (exam)			
Livedoid vasculopathy lesions (exam)			
Acute/chronic aPL-nephropathy (exam or lab)			
Pulmonary hemorrhage (symptoms and imaging)		Fetal death (16w 0d – 33w 6d) in the absence of pre-eclampsia (PEC) with severe features or placental insufficiency (PI) with severe features	1
Established (one or more of the following)	5		
Livedoid vasculopathy (pathology[d])		PEC with severe features (<34w 0d) or PI with severe features (<34w 0d) with/without fetal death	3
Acute/chronic aPL-nephropathy (pathology[d])			
Pulmonary hemorrhage (BAL or pathology[d])		PEC with severe features (<34w 0d) and PI with severe features (<34w 0d) with/without fetal death	4
Myocardial disease (imaging or pathology)			
Adrenal hemorrhage (imaging or pathology)			
D5. Cardiac Valve		**D6. Hematology**	
Thickening	2	Thrombocytopenia (lowest 20-130x10^9/L)	2
Vegetation	4		

Laboratory (aPL) domains and criteria[e]	Weight	Laboratory (aPL) domains and criteria[e]	Weight
D7. aPL test by coagulation-based functional assay (lupus anticoagulant test [LAC])		**D8. aPL test by solid phase assay (anti-cardiolipin antibody [aCL] ELISA and/or anti-β_2-glycoprotein-I antibody [aβ_2GPI] ELISA [persistent])**	
Positive LAC (single – one time)	1	Moderate or high positive (IgM) (aCL and/or aβ_2GPI)	1
Positive LAC (persistent)	5	Moderate positive (IgG) (aCL and/or aβ_2GPI)	4
		High positive (IgG) (aCL or aβ_2GPI)	5
		High positive (IgG) (aCL and aβ_2GPI)	7

TOTAL SCORE
Classify as Antiphospholipid Syndrome for research purposes if there are
at least 3 points from clinical domains AND at least 3 points from laboratory domains

Figure 1 2023 ACR/EULAR classification criteria. (a) Refer to table 1 for the definitions of clinical and laboratory criteria including the moderate- and high-titer anticardiolipin antibody (aCL) IgG/IgM or anti -β_2-glycoprotein I antibody (aβ_2GPI) IgG/IgM positivity. (b) Antiphospholipid antibody (aPL) positivity must be confirmed within +/ - three years of the documented (by medical records) clinical criterion. (c) Refer to table 2 for the definitions of high-risk profiles. (d) Suspected microvascular definition for each corresponding item should be first fulfilled. (e) For the purpose of laboratory domain scoring: 1) "persistent" aPL test results (at least 12 weeks apart) should be scored based on two consecutive positive lupus anticoagulant (LAC), two consecutive highest aCL, and/or two consecutive highest aβ_2GPI results (two consecutive results with one moderate positive and one high positive aCL/aβ_2GPI should be marked as "moderate positive" if there are no additional consecutive high results available); 2) for prospective data collection, two consecutive positive aPL results are required within three years of the clinical criterion; 3) for retrospective data collection, two consecutive positive aPL results and at least one positive aPL result within three years of the clinical criterion are required; 4) if there are multiple LAC assays performed on patients receiving anticoagulants (vitamin K antagonists, heparin, direct oral anticoagulants, indirect Factor Xa inhibitor), the results of the tests performed without anticoagulants should be included in the assessment unless the results of the tests performed with anticoagulants are reviewed/confirmed by an individual who has expertise in performing/interpreting the LAC assay (refer to table 1 for details); 5) moderate (40-79U) and high (>80U) level aCL/aβ_2GPI are based on enzyme-linked immunosorbent assays (ELISAs) (refer to table 1 for details); and 6) for prospective studies, the most recent aPL test (LAC and/or moderate-high level aCL/aβ_2GPI) should be positive to maintain homogeneity of research cohorts. BAL, bronchoalveolar lavage; CVD, cardiovascular disease; D1–D8, domains 1–8; exam, physical examination; lab, laboratory tests.

Table 3 Relative weights of additive classification criteria items based on 1000Minds analysis for antiphospholipid syndrome (APS) classification

Domain	Level	Original weight	Simplified weight*	Final weight
Clinical				
1. Macrovascular (venous thromboembolism (VTE))	A. No	0	0	0
	B. VTE with high-risk profile	1.3	0.4†	1
	C. VTE without high-risk profile	7.2	2.4‡	3
2. Macrovascular (arterial thrombosis (AT))	A. No	0	0	0
	B. AT with high-risk profile	6.1	2	2
	C. AT without high-risk profile	12.3	4.1	4
3. Microvascular	A. No	0	0	0
	B. Suspected	6.2	2.1	2
	C. Established	13.5	4.5	5
4. Obstetric	A. No	0	0	0
	B. ≥3 consecutive prefetal (<10 weeks) and/or early (10–16 weeks) fetal deaths, or≥1 fetal death (16–34 weeks) alone§	1.3	0.4†	1
	C. Preeclampsia with severe features OR placental insufficiency with severe features (<34 weeks) with or without fetal death¶	5.6	1.9 ‡	3
	D. Preeclampsia with severe features AND placental insufficiency with severe features (<34 weeks) with or without fetal death	12.3	4.1	4
5. Cardiac valve	A. No or not tested	0	0	0
	B. Valve thickening	6.1	2	2
	C. Valve vegetation	12.4	4.1	4
6. Haematology	A. No or not tested	0	0	0
	B. Thrombocytopenia (20–130×10^9/liter)	6.8	2.3	2
Laboratory				
7. Antiphospholipid antibody (aPL) testing by coagulation-based functional assays: lupus anticoagulant test	A. Negative or not tested	0	0	0
	B. Positive (single—one time)	9.4	3.1**	1
	C. Positive (persistent)	15.1	5	5
8. aPL testing by solid-phase assays: IgG/IgM anticardiolipin (aCL) and IgG/IgM anti–β_2-glycoprotein I (anti-β_2GPI) antibody enzyme-linked immunosorbent assay (persistent§§)	A. Negative or not tested	0	0	0
	B. Moderate or high positive (IgM alone) (aCL and/or anti-β_2GPI)††	1.3	0.4‡‡	1
	C. Moderate positive (IgG) (aCL and/or anti-β_2GPI)	10.8	3.6	4
	D. High positive (IgG) (aCL or anti-β_2GPI)	15	5	5
	E. High positive (IgG) (aCL and anti-β_2GPI)	20.4	6.8	7

*Simplified weights were calculated by dividing original weights by 3, followed by rounding up (for>0.5) or down (for<0.5), unless otherwise indicated.
†The simplified weight was rounded up to "1" to prevent a "0" score, as this clinical criterion would contribute to the APS classification score in the context of other low-scoring clinical criteria.
‡The simplified weight was rounded up to "3" as this criterion alone was determined to be sufficient for APS classification.
§One or more fetal death alone (no preeclampsia with severe features or placental insufficiency with severe features) between 16 weeks 0 days and 34 weeks 0 days of gestation was not scored during the 1000Minds exercise as the decision was to eventually apply the same score as obstetric level B.
¶Placental insufficiency with severe features was not scored during the 1000Minds exercise as the decision was to eventually apply the same score as for preeclampsia with severe features.
**The simplified weight was reduced to "1" due to an unexpected high proportion relative to the persistent lupus anticoagulant (LAC) positivity, and to decrease the likelihood of a case with a single test showing postive for LAC to be classified as APS.
††Moderate-level (40–79 units) and high-level (≥80 units) aCL/anti-β_2GPI are based on enzyme-linked immunosorbent assays (refer to table 1 for details).
‡‡The simplified weight was rounded up to "1" to prevent a "0" score.
§§"Persistent" defined as a positive result on at least 2 occasions, at least 12 weeks apart.

literature review and expert consensus, improve the reliability and precision of classification; (2) the criteria are differentially weighted and organised into eight hierarchical domains; and (3) the criteria were validated based on two international cohorts of patients referred for suspicion of APS, demonstrating very high specificity (99%) relative to the revised Sapporo criteria (86%).

In contrast to making a diagnosis, which requires consideration of a broad range of features (including rare ones), available clinical tests, and differential diagnoses pertaining to the epidemiology in a specific region, the goal of classification criteria is to enrol individuals with a condition of interest manifesting key features of the disease to form relatively homogeneous cohorts for comparability across clinical studies and trials.[32] Thus, classification criteria intentionally include standardised and stringent definitions[32]; very high specificity is required, even at the cost of sensitivity. Our goal was to achieve high specificity relative to the revised Sapporo criteria to improve homogeneity in APS research. While 99% specificity is a highly desirable performance characteristic of the new criteria for clinical trials and studies, the sensitivity of 84% captures a broad spectrum of patients referred for APS suspicion in whom the investigators are confident of APS classification.

Table 4 Demographic and clinical characteristics of 553 cases used in both validation cohorts, by independent adjudicators' consensus for antiphospholipid syndrome (APS) classification

Characteristic	Validation cohort 1 (n=278)		Validation cohort 2 (n=275)	
	APS (n=98)	No APS (n=180)	APS (n=113)	No APS (n=162)
Demographics				
Age, mean±SD years	45.2±14.7	43.3±14.5	43.2±12.9	42.8±14.7
Age range, years	20–84	20–84	18–85	18–85
Female, no. (%)	73 (75)	143 (79)	88 (78)	136 (84)
Race, no. (%)				
Asian	6 (6)	15 (8)	7 (6)	16 (10)
Black	2 (2)	6 (3)	5 (4)	13 (8)
Other	4 (4)	4 (2)	6 (4)	6 (4)
White	86 (88)	155 (86)	95 (84)	127 (8)
Ethnicity, no. (%)				
Hispanic/Latin American	12 (12)	13 (7)	10 (9)	23 (14)
Not allowed to record	10 (10)	6 (3)	11 (10)	10 (6)
Not Hispanic/Latin American	61 (62)	141 (78)	78 (69)	103 (64)
Other	15 (15)	20 (11)	14 (12)	26 (16)
Region of residence, no. (%)				
Asia	4 (4)	5 (3)	3 (3)	9 (6)
Europe	52 (53)	121 (67)	66 (58)	92 (57)
North America	38 (39)	47(26)	40 (35)	54 (33)
South America	4 (4)	7 (4)	4 (4)	(7 (5)
Other systemic rheumatic disease, no. (%)				
Systemic lupus erythematosus	30 (31)	59 (33)	42 (37)	50 (31)
Other*	2 (2)	9 (5)	3 (3)	12 (7)
Entry criteria, no. (%)				
Met	98 (100)	58 (32)	113 (100)	55 (34)
Not met	0	122 (68)	0	107 (66)
Clinical characteristics				
Macrovascular (any), no. (%)	76 (78)	60 (33)	87 (77)	46 (28)
Venous thromboembolism	52 (53)	38 (21)	62 (55)	32 (20)
Arterial thrombosis	38 (39)	25 (14)	44 (39)	19 (12)
Microvascular, no. (%)	18 (18)	7 (4)	30 (27)	14 (9)
Pregnancy morbidity (any), no./total (%)	34/73 (47)	41/143 (29)	46/88 (52)	53/136 (33)
≥1 prefetal death<10 weeks	15/34 (44)	35/41 (85)	19/46 (41)	39/53 (74)
≥1 early fetal death 10–16 weeks	1/34 (3)	3/41 (7)	8/46 (17)	3/53 (6)
≥1 fetal death 16–34 weeks only, without preeclampsia or placental insufficiency	10/34 (29)	7/41 (17)	14/46 (30)	4/53 (8)
Preeclampsia and/or placental insufficiency (with or without fetal death)	15/34 (44)	8/41 (20)	20/46 (44)	14/53 (26)
Cardiac valve, no. (%)				
Thickening only	4 (4)	5 (3)	4 (4)	2 (1)
Vegetation (with or without thickening)	3 (3)	3 (2)	9 (8)	0
Hematologic, no. (%)				
Thrombocytopenia	24 (25)	23 (13)	27 (24)	28 (17)
Laboratory characteristics†				
Lupus anticoagulant positive, no. (%)				
Positive (single-once)	10 (10)	13 (7)	4 (4)	14 (9)
Positive (persistent)	72 (74)	41 (23)	97 (86)	41 (25)
IgG/IgM aCL/anti-β_2GPI positive, no. (%)‡				
Moderate or high positive (IgM alone) (aCL and/or anti-β_2GPI)	13 (13)	8 (4)	11 (10)	8 (5)
Moderate positive (IgG) (aCL and/or anti-β_2GPI) with or without IgM	16 (16)	9 (5)	10 (9)	11(7)
High positive (IgG) (aCL or anti-β_2GPI) with or without IgM	19 (19)	2 (1)	22 (20)	8 (5)
High positive (IgG) (aCL and anti-β_2GPI) with or without IgM	21 (21)	5 (3)	26 (23)	3 (2)

*Based on the case collector physician's diagnosis, "other" systemic rheumatic diseases reported included Behçet's disease (n=1), IgG4-related disease (n=1), mixed connective tissue disorder (n=6), polymyalgia rheumatica (n=1), rheumatoid arthritis (n=4), Sjögren's syndrome (n=7), spondyloarthropathy (n=4), and systemic sclerosis (n=2).
†Based on the case collector physician's assessment of antiphospholipid antibody positivity.
‡Moderate (40–79 units) and high (≥80 units) positive anticardiolipin (aCL)/anti–β_2-glycoprotein I (anti-β_2GPI) antibodies are based on enzyme-linked immunosorbent assays (refer to table 1 for details).

Table 5 Operating characteristics of the 2023 ACR/EULAR antiphospholipid syndrome (APS) classification criteria versus the revised Sapporo APS classification criteria compared against independent adjudicators' consensus in two distinct validation cohorts

	Validation cohort 1 (n=278)		Validation cohort 2 (n=275)	
	2023 ACR/EULAR APS criteria	Revised Sapporo APS criteria	2023 ACR/EULAR APS criteria	Revised Sapporo APS criteria
Criteria met, no. of subjects	83	120	97	143
Specificity (95% CI)	0.99 (0.98 to 1.00)	0.91 (0.86 to 0.95)	0.99 (0.97 to 1.00)	0.86 (0.81 to 0.92)
Sensitivity (95% CI)	0.83 (0.75 to 0.90)	1.00 (1.00 to 1.00)	0.84 (0.77 to 0.91)	0.99 (0.98 to 1.00)

95% CI, 95% confidence interval.

The novel clinical features of the new APS classification criteria include the following: (1) risk stratification of macrovascular events by traditional thrombosis risk factors (although the revised Sapporo criteria acknowledged the need to recognise subgroups with and without thrombosis risk factors [2], our criteria are the first to offer a weighted assessment); (2) well-defined microvascular domain items thought to be mechanistically distinct from moderate-to-large vessel disease; (3) re-structured definitions of pregnancy morbidity to improve patient selection in obstetric studies; and (4) the addition of cardiac valve disease and thrombocytopenia, to capture and quantify the magnitude of heterogeneous APS manifestations.

The novel laboratory features of the new APS classification criteria include the following: (1) quantifying single-, double-, and triple-aPL positivity based on different domains and weights; (2) separating aCL/anti-β_2GPI IgG and IgM isotypes, to avoid including aPL-positive patients with isolated aCL/anti-β_2GPI IgM isotypes (ie, no other aPL positivity) in the same research studies as those with aCL/anti-β_2GPI I IgG isotypes; and (3) defining 2 levels of aCL/anti-β_2GPI positivity that will be interpreted as clinically relevant by most investigators. These decisions were based on literature reviews,[33] Phase III-C relative risk analyses,[30] and Steering Committee consensus (for details as well as the rationale for not including IgA isotypes or other solid-phase assay–based aPL tests, see online supplemental section 5). Although the Steering Committee agreed that only LAC assays and aCL/anti-β_2GPI ELISAs should be included to ensure homogeneity, because automated laboratory systems are increasingly used in various countries, the Steering Committee suggested further studying the moderate/high thresholds in new automated platforms in association with clinical criteria from the new classification criteria (table 1).

During the development and validation phases, we identified 3 "controversial" clinical scenarios not meeting the APS classification threshold by Steering Committee consensus but rated as APS by outside adjudicators, that is, "false negatives" by the new criteria. These scenarios, and others below the threshold, are equivocal or uncertain for classification purposes, given the lack of strong literature support and physician agreement. Because the Steering Committee achieved a clear APS classification threshold above the controversial cases, as supported by the literature, and agreed that highly specific classification criteria are imperative for achieving homogeneity in APS research, along with ethical concerns of enrolling patients with controversial scenarios in the same clinical trials (e.g., trials of long-term anticoagulation therapy) as patients with highly likely APS, the Steering Committee deemed it acceptable to exclude these subgroups from current APS classification but to further study them independently (table 6).

While using the new classification criteria, researchers should pay attention to certain points. First, clinical expertise and attentiveness are required to attribute clinical criteria to APS; as this can be challenging when "equally or more likely" causes exist, the item in question should not be scored. For example, in the clinical scenario of an acceptable aPL profile and concomitant heparin-induced thrombocytopenia, the hematologic domain should not be scored. Similarly, in a patient with systemic lupus erythematosus (SLE) with an acceptable aPL profile and preeclampsia, the obstetric item should not be scored if the preeclampsia can be equally or more likely explained as attributable to SLE. Second, as the primary goal is to ensure high-quality prospective studies and clinical trials, complete information on patients' VTE and CVD risk profiles is essential to evaluate the macrovascular domain. However, immediate real-world implementation of this concept may be challenging for retrospective studies, due to inadequate documentation including risk factor data. In this case, the Steering Committee agreed with taking a conservative bias approach such that the lowest possible non-zero weight should be assigned to macrovascular domain items with unknown risk factor data to avoid

Table 6 High-priority antiphospholipid syndrome (APS) research agenda to guide the future update of the 2023 ACR/EULAR APS classification criteria

Patients with clinical AND laboratory criteria but NOT fulfilling the APS classification criteria	► Venous thromboembolism (VTE) or arterial thrombosis (AT) alone, that is, no other clinical criteria, in patients with high-risk VTE or CVD profiles, AND laboratory criteria score≥3 ► Otherwise unexplained three or more consecutive prefetal deaths (<10 weeks) and/or early fetal death (10 weeks 0 days to 15 weeks 6 days) alone, that is, no other clinical criteria, AND laboratory criteria score≥3 ► Otherwise unexplained one or more fetal death (16 weeks 0 days to 34 weeks 0 days) alone, that is, no other clinical criteria, AND laboratory criteria score≥3 ► Moderate-titre (40–79 units) or high-titre (≥80) IgM anticardiolipin (aCL) or IgM anti–β_2-glycoprotein I (anti-β_2GPI) antibodies based on enzyme-linked immunosorbent assays (ELISAs) alone, that is, no other antiphospholipid antibody (aPL) test positivity, and clinical criteria score≥3
Patients fulfilling the clinical criteria but NOT the laboratory criteria	► Other aCL/anti-β_2GPI testing platforms, for example, automated laboratory systems, to determine the "moderate" and "high" thresholds corresponding to ELISA ► "Other" solid-phase assay–based aPL tests to determine their relevance
Patients fulfilling the laboratory criteria but NOT the clinical criteria	► "Other" potential aPL-related clinical manifestations to determine their specificity and frequency (see ref. 8)

APS misclassification. Finally, the accurate assessment of "positive" aPL test results for APS classification is critical due to the following reasons: (1) despite LAC test limitations, i.e., false negative/positive results, the Steering Committee agreed that the test is extremely important if performed according to ISTH guidelines[27]; and (2) defined levels for "moderate" and "high" positivity apply to ELISA tests but not to other methodologies, e.g., automated platforms.[33]

The 2023 ACR/EULAR APS classification criteria have several strengths. First, international cases capturing the spectrum of APS contributed to its development, reducing the risk of selection bias and increasing generalizability. Second, to avoid the bias of circular reasoning,[34] multidisciplinary participants in Phases III and IV were distinct. Third, use of 2 independent validation cohorts ultimately strengthened our results, demonstrating similar performance characteristics with overlapping confidence intervals. In fact, as the criteria were not changed between the two validation cohorts, our Phase IV results can be viewed as a single validation cohort with an interim analysis. Fourth, the new classification system allows for individual domain modification, allowing for future incorporation of additional clinical or new commercially available laboratory items if shown to be highly specific for APS, or new VTE and CVD risk factors based on future guidelines. Fifth, our criteria incorporate "entry criteria" to reflect current thinking that only cases with at least a minimal degree of clinical and laboratory suspicion for APS should be considered for classification. By intentionally collecting suspected APS cases for validation, we were able to test our entry criteria in a sensitivity analysis. Last, our model with absolute point requirements from both clinical and laboratory domains refines previous single-threshold models and more accurately reflects actual APS clinical decision-making.

As a limitation, our cohorts do not represent all possible subpopulations; however, we anticipate that investigators will test external validity in other cohorts, for example, aPL-positive SLE patients, non-White race/ethnicities, paediatrics, or nonacademic cohorts. The Steering Committee emphasised that large population-based studies in APS, accounting for social determinants of health and access to care, are needed to better establish disease prevalence overall and across sociodemographic groups. Absent a definitive gold standard, validating a classification system for an evolving disease definition such as APS can be challenging. As acknowledged by other classification criteria development efforts,[10] although independent adjudicators may have inherent biases toward established criteria, our careful selection of individuals, based on the adjudicators' expertise and with the adjudicators being blinded to relevant discussions about literature review and expert consensus–based decisions, reduced the bias of circular reasoning. Furthermore, the opportunity for adjudicators to discuss controversial cases in-depth, and to achieve consensus on all cases except one, ultimately strengthened their combined opinion.

In conclusion, using rigorous data-driven and expert-based methodology, including international multidisciplinary collaborators with APS expertise, methodologists, and patients, we have incorporated heterogenous aPL-related clinical and laboratory manifestations into a set of hierarchically clustered, weighted, and risk-stratified classification criteria reflecting current thinking about APS, providing high specificity and an improved foundation for APS research.

Author affiliations
[1]Barbara Volcker Center for Women and Rheumatic Diseases, Hospital for Special Surgery, Weill Cornell Medicine, New York, New York, USA
[2]Vascular Medicine Division, French National Referral Center for Systemic and Autoimmune Diseases, Université de Lorraine, Inserm, DCAC, and CHRU-Nancy, Nancy, France
[3]Department of Medicine and Obstetrics, Auckland City Hospital, Auckland, New Zealand
[4]Department of General Medicine, Middlemore Hospital, Auckland, New Zealand
[5]CIC Clinical Epidemiology, CHRU Nancy, Inserm, Université de Lorraine, Nancy, France
[6]Department of Internal Medicine, Service of Rheumatology, ABC Medical Center, Mexico, Mexico
[7]French National Reference Center for Systemic Lupus Erythematosus, Antiphospholipid Antibody Syndrome, Service de Medecine Interne 2, Hopital Pitie-Salpetriére; Centre d'Immunologie et des Maladies Infectieuses, Sorbonne Universite, Paris, France
[8]Department of Rheumatology, University of Sao Paulo, Sao Paulo, Brazil
[9]Rheumatology and Clinical Immunology Unit, ASST Spedali Civili, Department of Clinical and Experimental Science, University of Brescia, Brescia, Italy
[10]Department of Rheumatology, Istanbul University School of Medicine, Istanbul, Turkey
[11]Department of Rheumatology, Endocrinology, and Nephrology, Hokkaido University, Sapporo, Japan
[12]Department of Allergology, Rheumatology, and Clinical Immunology, Children's Hospital, University Medical Center, University of Ljubljana, Ljubljana, Slovenia
[13]Department of Rheumatology, Hospital for Joint Disease, New York University, New York, New York, USA
[14]Academic Department of Vascular Surgery, School of Cardiovascular and Metabolic Medicine & Sciences, King's College, London, UK
[15]Department of Obstetrics and Gynecology, University of Utah Health, Salt Lake City, Utah, USA
[16]Unidade de Imunologia Clínica, Departamento de Medicina Interna, Hospital de Santo António, Centro Hospitalar do Porto, Porto, Portugal
[17]Division of Angiology and Hemostasis, University Hospital of Geneva, Geneva, Switzerland
[18]Department of Autoimmune Diseases, Hospital Clinic, University of Barcelona, Barcelona, Spain
[19]Department of Haematology, University College London, London, UK
[20]Service de médecine interne, Centre de reference maladies autoimmunes et systémiques rares Île de France, APHP, Hopital Cochin, Université de Paris, Centre de recherche épidémiologie et biostatistiques de Sorbonne Paris Cité, Paris, France
[21]Department of Medicine, McMaster University, Hamilton, Ontario, Canada
[22]Department of Obstetrics, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil
[23]Department of Medicine, University Ottawa, and the Ottawa Hospital Research Institute, Ottawa, Ontario, Canada
[24]Division of Rheumatology, University of California, Irvine, California, USA
[25]Division of Hematology and Oncology, Weill Cornell Medicine, New York, New York, USA
[26]Coagulation Laboratory, Department of Laboratory Medicine, Ghent University Hospital, Ghent, Belgium
[27]Department of Diagnostic Sciences, Ghent University, Ghent, Belgium
[28]Department of Molecular Biology and Genetics, Istanbul University School of Science, Istanbul, Turkey
[29]Division of Rheumatology, Mayo Clinic, Rochester, Minnesota, USA
[30]Department of Dermatology-Allergology, Tenon Hospital, Paris, France
[31]Department of Hematology, University of Washington, Seattle, Washington, USA
[32]Department of Hematology, CHRU-Nimes, UMR UA11 INSERM-University of Montpellier, Montpellier, France
[33]Department of Rheumatology, Addenbrooke's Hospital, Cambridge, UK
[34]Department of Hematology, Massachusetts General Hospital, Boston, Massachusetts, USA
[35]Division of Rheumatology, Northwell Health, Great Neck, New York, New York, USA
[36]Division of Rheumatology, University of Michigan, Ann Arbor, Michigan, USA
[37]Division of Rheumatology, University of Toronto, TRIO Fertility, Toronto, Ontario, Canada
[38]Department of Hematology, Yale School of Medicine, New Haven, Connecticut, USA
[39]Division of Rheumatology, McMaster University, Hamilton, Ontario, Canada
[40]Downstate Stroke Center, State University of New York Downstate Health Sciences University, Kings County Hospital Center, and Maimonides Medical Center/Jaffe Stroke Center, Brooklyn, New York, USA
[41]Department of Rheumatology, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil
[42]GlaxoSmithKline, Collegeville, Pennsylvania, USA
[43]Department of Medicine and Clinical Immunology, University Medical Center, Utrecht University, Utrecht, The Netherlands
[44]Department of Obstetrics, Medizinische Universität Graz, Österreich, Austria
[45]Department of Medicine, Jagiellonian University School of Medicine, Krakow, Poland

[46]Immunorheumatology Research Laboratory, IRCCS Istituto Auxologico Italiano, Milan, Italy
[47]Department of Rheumatology, University Hospitals of Verona, Verona, Italy
[48]Division of Hematology, Duke University Medical Center, Durham, North Carolina, USA
[49]Department of Cardiology, University Hospital, Padova, Italy
[50]Division of Rheumatology, Johns Hopkins University School of Medicine, Baltimore, Maryland, USA
[51]Department of Rheumatology, Grupo Oroño-Centro Regional de Enfermedades Autoinmunes y Reumáticas (GO-CREAR), Rosario, Argentina
[52]Department of Rheumatology, Hospital Clinic and IDIBAPS, Barcelona, Spain
[53]Department of Nephrology, Bichat University Hospital, Paris, France
[54]Department of Rheumatology, University of North Carolina, Chapel Hill, North Carolina, USA
[55]Department of Rheumatology, Guy's and St Thomas' NHS Foundation Trust, London, UK
[56]Department of Pathology and Laboratory Medicine, Weill Cornell Medicine, New York, New York, USA
[57]Department of Clinical and Biological Sciences, Center of Research of Immunopathology and Rare Diseases, SCDU Nephrology and Dialysis, S. Giovanni Bosco Hospital, Turin, Italy
[58]University of Turin, Torino, Italy
[59]Joint Academic Rheumatology Program, First Propaedeutic and Internal Medicine Program, National and Kapodistrian University of Athens, Athens, Greece
[60]Antiphospholipid Standardization Laboratory, University of Texas Medical Branch, Galveston, Texas, USA
[61]Department of Internal Medicine and Immunology, Université de Lille, CHU Lille, INSERM, UMR 1167, Lille, France
[62]Department of Obstetrics, Université de Lorraine, Inserm, DCAC, and CHRU-Nancy, Nancy, France
[63]Department of Rheumatology, Brigham and Women's Hospital, Boston, Massachusetts, USA

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Contributors Study conception and design. Barbhaiya, Zuily, Naden, Amigo, Avcin, Bertolaccini, Branch, de Jesus, Devreese, Frances, Garcia, Levine, Levy, Lockshin, Ortel, Seshan, Tektonidou, Wahl, Willis, Guillemin, Costenbader, Erkan. Acquisition of data. Barbhaiya, Zuily, Amigo, Andrade, Andreoli, Artim-Esen, Atsumi, Avcin, Belmont, Bertolaccini, Branch, Carvalheiras, Casini, Cervera, Costedoat-Chalumeau, de Jesus, Delluc, Desai, De Sancho, Devreese, Diz-Kucukkaya, Duarte-Garcia, Gris, Jordan, Leaf, Kello, Knight, Laskin, Lee, Legault, Levine, Limper, MayerPickel, Musial, Meroni, Orsolini, Pengo, Petri, Pons-Estel, Gomez Puerta, Raimboug, Sanna, Sciascia, Tektonidou, Tincani, Wahl, Willis, Yelnik, Zuily, Costenbader, Erkan. Analysis and interpretation of data. Barbhaiya, Zuily, Naden, Hendry, Amigo, Amoura, Avcin, Bertolaccini, Branch, Cohen, Crowther, de Jesus, Devreese, Frances, Garcia, Levine, Levy, Lockshin, Manneville, Ortel, Roubey, Seshan, Tektonidou, Wahl, Willis, Guillemin, Costenbader, Erkan.

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ORCID iDs
Medha Barbhaiya http://orcid.org/0000-0002-6670-7696
Stephane Zuily http://orcid.org/0000-0002-9326-6881
Danieli Andrade http://orcid.org/0000-0002-0381-1808
Laura Andreoli http://orcid.org/0000-0002-9107-3218
Michael H Belmont http://orcid.org/0000-0003-3389-2976
Nathalie Costedoat-Chalumeau http://orcid.org/0000-0002-1555-9021
Guilherme de Jesús http://orcid.org/0000-0002-6715-0180
Ali Duarte-García http://orcid.org/0000-0003-1749-5719
Jean-Christophe Gris http://orcid.org/0000-0002-9899-9910
Nina Kello http://orcid.org/0000-0001-5497-7472
Jason S Knight http://orcid.org/0000-0003-0995-9771
Roger A Levy http://orcid.org/0000-0001-6393-6031
Pier Luigi Meroni http://orcid.org/0000-0002-3394-1451
Giovanni Orsolini http://orcid.org/0000-0003-4119-3016
Vittorio Pengo http://orcid.org/0000-0003-2064-6071
Michelle Petri http://orcid.org/0000-0003-1441-5373
Guillermo Pons-Estel http://orcid.org/0000-0002-0647-929X
Savino Sciascia http://orcid.org/0000-0003-1266-9441
Maria G Tektonidou http://orcid.org/0000-0003-2238-0975
Karen Costenbader http://orcid.org/0000-0002-8972-9388
Doruk Erkan http://orcid.org/0000-0001-7216-677X

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