

Table S1. Clinical baseline characteristics of healthy controls and SLE patients

	Healthy control	Systemic lupus erythematosus	P value
Cohort demographics			
Sample size	26	48	
Age (years)	40.00±9.42	36.25±11.80	0.072
Female, n (%)	19 (73.1%)	43 (89.6%)	0.131
Patient characteristics			
SLE duration (months)	-	75.85±67.18	-
Activity, n (%)	-	22 (45.8%)	-
Lupus nephritis, n (%)	-	29 (60.4%)	-
Hypertension, n (%)	-	12 (25%)	-
Laboratory parameters			
Albumin (g/l) ***	42.80±2.99	35.78±6.31	< 0.001
Globulin (g/l) **	30.31±3.52	27.54±5.52	0.005
Total cholesterol (mmol/l)	28.49±116.41	5.10±1.37	0.353
Triglyceride (mmol/l)	1.95±3.52	1.86±1.60	0.134
White blood cell ($\times 10^9/l$)	6.49±1.22	6.92±3.11	0.986
Hemoglobin (g/l) ***	141.38±14.46	114.52±23.81	< 0.001
Platelet ($\times 10^9/l$) *	281.54±71.29	229.73±73.71	0.010
Neutrophil ($\times 10^9/l$)	3.88±0.87	4.74±2.68	0.545
Prothrombin time (s)	-	11.58±1.26	-
Prothrombin activity (%)	-	110.61±14.61	-
International normalized ratio (INR)	-	0.93±0.07	-
Activated partial thromboplastin time (s)	-	29.33±7.18	-
Thrombin time (s)	-	17.70±0.94	-
Fibrinogen (mmol/l)	-	2.80±0.82	-
D2 polymers (mg/l)	-	1.62±3.93	-
Fibrinogen degradation product ($\mu g/ml$)	-	3.14±4.38	-
IL-1 β (pg/ml)	-	138.42±168.88	-
IFN- $\alpha 2$ (pg/ml)	-	31.89±44.59	-
IFN- γ (pg/ml)	-	68.35±277.08	-
TNF- α (pg/ml)	-	198.27±823.14	-
MCP-1 (pg/ml)	-	828.74±1220.30	-
IL-6 (pg/ml)	-	48.50±63.67	-
IL-8 (pg/ml)	-	194.63±224.96	-
IL-10 (pg/ml)	-	70.98±96.76	-
IL-12p70 (pg/ml)	-	29.42±25.29	-
IL-17A (pg/ml)	-	11.04±15.55	-
IL-18 (pg/ml)	-	2727.58±3646.18	-
IL-23 (pg/ml)	-	56.64±95.06	-
IL-33 (pg/ml)	-	408.72±379.15	-

	Healthy control	Systemic lupus erythematosus	P value
Total IgA (g/l)	-	2.24±0.95	-
Total IgG (g/l)	-	11.00±4.27	-
Total IgM (g/l)	-	0.96±0.62	-
Anti-PS/PT IgA (ng/ml)	118.12±266.87	53.19±61.89	0.112
Anti-PS/PT IgG (ng/ml)	129.74±343.37	55.71±147.90	0.109
Anti-PS/PT IgM (ng/ml) **	99.94±147.90	41.02±101.65	0.002
Anti-PT IgA (ng/ml)	142.02±327.00	32.81±140.87	0.108
Anti-PT IgG (ng/ml) ***	111.00±212.91	93.25±85.26	< 0.001
Anti-PT IgM (ng/ml) **	36.71±66.82	14.12±16.64	0.008
Anti-PS IgA (OD450nm) **	0.29±0.14	0.50±0.33	0.004
Anti-PS IgG (OD450nm) *	0.36±0.03	0.40±0.08	0.047
Anti-PS IgM (OD450nm) ***	0.55±0.23	0.36±0.18	< 0.001
Anti-dsDNA IgG (IU/ml) ***	16.82±48.54	159.68±198.85	< 0.001
PS-IgG IC (OD450nm) ***	0.77±0.15	0.98±0.27	< 0.001
PS-IgM IC (OD450nm)	1.13±0.32	0.99±0.40	0.085
SLEDAI ¹	-	6.27±6.11	-
C3 ² (g/l)	-	0.74±0.24	-
C4 ³ (g/l)	-	0.15±0.08	-
Serum creatinine (μmol/l)	64.88±14.06	100.38±93.87	0.356
Blood urea nitrogen (mmol/l)	4.03±0.99	7.42±7.69	0.267
eGFR ⁴ (ml/min/1.73m ²)	109.83±19.16	91.34±36.63	0.085

Data were expressed as mean ± SD.

¹ SLEDAI: Systemic lupus erythematosus disease activity index; ² C3: Complement 3;

³ C4: Complement 4; ⁴ eGFR: estimated Glomerular filtration rate.

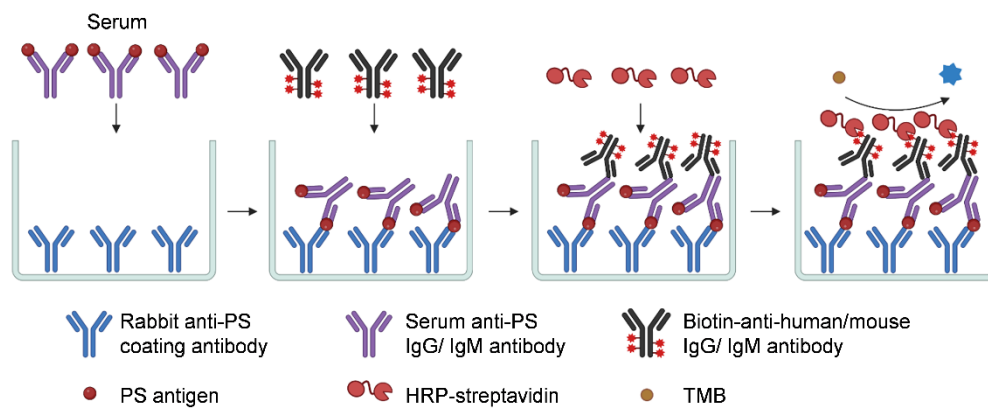


Figure S1. Flow chart for detection of serum PS-IgG/ IgM IC by ELISA assay

Table S2. Antibodies used in the study

Antibody	Manufacturer	Catalog #	Clone	Applications
Human				
Rabbit anti-PS antibody	Cloud-Clone	PAB881Ge01	-	ELISA (1:1000)
Biotin anti-human IgG antibody	BioLegend	366918	QA19A42	ELISA (1:1000)
HRP goat anti-human IgA antibody	BioLegend	411002	Poly24110	ELISA (1:1000)
Biotin anti-human IgM antibody	BioLegend	314504	MHM-88	ELISA (1:1000)
Goat anti-human IgG antibody	Abcam	AB6714	-	IF (1:500)
HRP rabbit anti-goat antibody	Servicebio	GB23204	-	IF (1:500)
HRP goat anti-rabbit antibody	Servicebio	GB23303	-	IF (1:500)
Rabbit anti-human IgG antibody	ABclonal	A19711	-	WB (1:2000)
HRP-goat anti-rabbit antibody	Fdbio	FDR007	-	WB (1:5000)
PerCP/Cyanine5.5 anti-human CD4 antibody	BioLegend	317428	OKT4	FC (1:300)
Brilliant violet 421 anti-human CD19 antibody	BioLegend	302234	HIB19	FC (1:300)
APC-anti-human CD86 antibody	BioLegend	305411	IT2.2	FC (1:300)
PE/Cyanine7 anti-human CD206 antibody	BioLegend	321123	15.2	FC (1:300)
PE anti-human CD14 antibody	BioLegend	367103	63D3	FC (1:300)
Biotin anti-human CD14 antibody	BioLegend	325624	HCD14	FC (1:300)
Brilliant Violet 421 streptavidin	BioLegend	405226	-	FC (1:300)
APC streptavidin	BioLegend	405207	-	FC (1:300)
FITC streptavidin	BioLegend	405201	-	FC (1:300)
Human TruStain FcX	BioLegend	422302		FC (1:300)
Mouse				

Antibody	Manufacturer	Catalog #	Clone	Applications
Biotin anti-mouse IgG antibody	BioLegend	405303	Poly4053	ELISA (1:1000)
CY3-goat anti-rabbit antibody	Servicebio	GB21303	-	IF (1:500)
Alexa Fluor 488 goat anti-mouse IgG antibody	BioLegend	405319	Poly4053	IF (1:500)
Mouse TruStain FcX	BioLegend	101320	-	FC (1:300)
APC/Cyanine7 anti-mouse Ly-6G antibody	BioLegend	127627	1A8	FC (1:300)
APC anti-mouse/human CD11b antibody	BioLegend	101212	M1/70	FC (1:300)
PE anti-mouse CD45 antibody	BioLegend	103106	30-F11	FC (1:300)
Brilliant violet 421 anti-mouse CD45 antibody	BioLegend	103133	30-F11	FC (1:300)

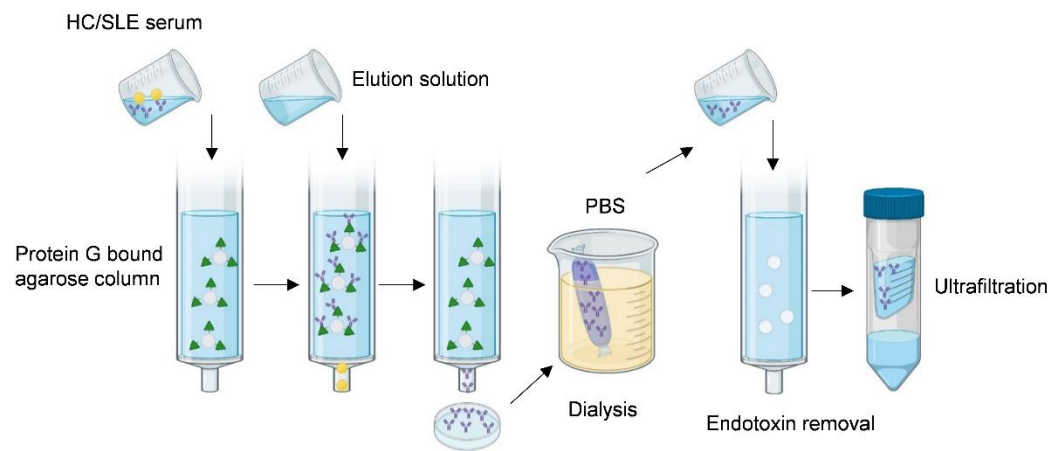


Figure S2. Flow chart for purification of serum IgG of HC and SLE patients

Table S3. Comparison of clinical characteristics between high and low PS-IgG**subgroups in SLE patients**

Clinical and laboratory indicators	Patients with low anti-PS IgG levels	Patients with high anti-PS IgG levels	P value
Sample size	24	24	
Female, n (%)	23 (95.8%)	20 (83.3%)	0.345
Age (years)	37.17±12.10	35.46±11.47	0.749
BMI ¹ (kg/m ²)	21.84±3.44	22.50±3.19	0.444
SLE duration (months)	83.68±70.48	68.02±64.24	0.409
Lupus nephritis, n (%)	13 (54.2%)	16 (66.7%)	0.376
Hypertension, n (%)	8 (33.3%)	4 (16.7%)	0.185
IL-1β (pg/ml)	137.82±207.37	139.02±123.60	0.323
IFN-α2 (pg/ml)	22.59±20.89	41.19±58.70	0.455
IFN-γ (pg/ml)	106.96±390.59	29.74±34.79	0.680
TNF-α (pg/ml)	93.19±91.03	303.35±1163.30	0.628
MCP-1 (pg/ml)	610.37±705.44	1047.10±1563.93	0.353
IL-6 (pg/ml)	48.94±77.35	48.07±47.97	0.457
IL-8 (pg/ml)	261.49±285.43	127.77±112.31	0.392
IL-10 (pg/ml)	75.48±118.52	66.48±71.01	0.576
IL-12p70 (pg/ml)	31.61±28.41	27.22±22.12	0.909
IL-17A (pg/ml)	14.75±19.26	7.33±9.73	0.151
IL-18 (pg/ml)	2841.05±4507.52	2614.12±2612.02	0.757
IL-23 (pg/ml)	79.90±119.88	33.39±54.48	0.537
IL-33 (pg/ml)	432.82±390.14	384.62±374.63	0.703
Total IgA (g/l)	1.95±0.68	2.54±1.10	0.053
Total IgG (g/l) *	9.35±3.39	12.65±4.49	0.011
Total IgM (g/l)	1.06±0.61	0.87±0.63	0.143
Anti-PS/PT IgA (ng/ml)	45.30±70.12	61.08±52.72	0.051
Anti-PS/PT IgG (ng/ml)	27.73±17.76	83.70±206.77	0.143
Anti-PS/PT IgM (ng/ml)	57.92±142.93	24.13±9.53	0.201
Anti-PT IgA (ng/ml)	51.09±199.08	14.53±14.88	0.942
Anti-PT IgG (ng/ml)	95.43±111.47	91.07±49.18	0.265
Anti-PT IgM (ng/ml)	16.89±22.86	11.36±5.22	0.599
Anti-PS IgA (OD450nm) *	0.39±0.24	0.61±0.37	0.044
Anti-PS IgM (OD450nm)	0.37±0.19	0.36±0.17	0.967
Anti-dsDNA IgG (IU/ml) *	65.15±63.99	254.21±240.95	0.002
PS-IgG IC (OD450nm) ***	0.83±0.21	1.12±0.24	< 0.001
PS-IgM IC (OD450nm)	1.01±0.41	0.96±0.40	0.853

Clinical and laboratory indicators	Patients with low anti-PS IgG levels	Patients with high anti-PS IgG levels	P value
SLEDAI ² *	3.92±3.36	8.63±7.31	0.011
C3 ³ (g/l) *	0.84±0.18	0.63±0.26	0.003
C4 ⁴ (g/l) *	0.19±0.07	0.11±0.06	< 0.001
Urine protein (g/24h)	1.24±2.03	1.42±2.67	0.533
Hematuria, n (%)	6 (25.0%)	5 (20.8%)	0.731
Pyuria, n (%) *	1 (4.2%)	8 (33.3%)	0.027
Serum creatinine (μmol/l)	119.79±121.33	80.96±49.97	0.332
Blood urea nitrogen (mmol/l)	8.60±9.20	6.24±5.78	0.749
eGFR ⁵ (ml/min/1.73m ²)	84.55±39.19	98.12±33.32	0.149

Data were expressed as mean ± SD.

¹ BMI: Body mass index; ² SLEDAI: Systemic lupus erythematosus disease activity index; ³ C3: Complement 3; ⁴ C4: Complement 4; ⁵ eGFR: estimated Glomerular filtration rate.

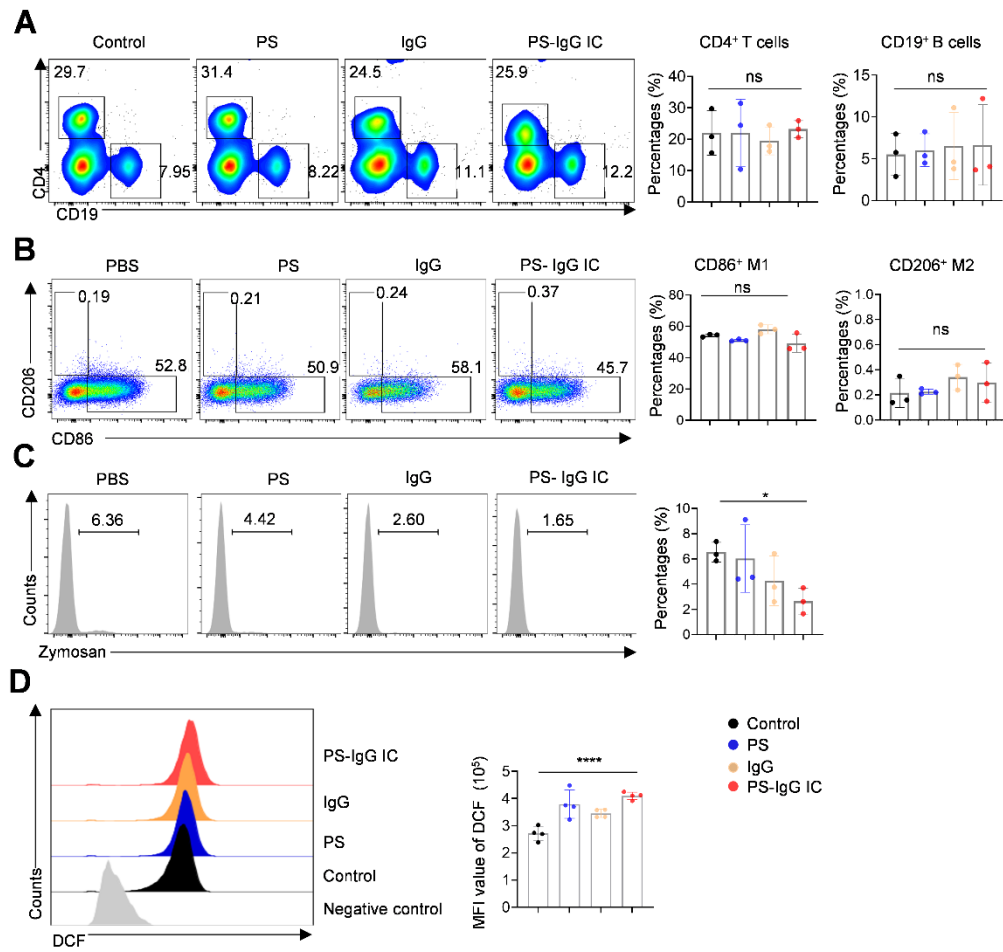


Figure S3. The effect of PS-IgG IC on macrophages derived from THP-1 cell line. (A) The effect of PS-IgG IC on the proportion of T cells, and B cells in PBMC. PBMCs from SLE patients were polarized by M-CSF for 5 days, then treated with PS, purified IgG or PS-IgG IC for 12 hours. The flow cytometric images and data plots show the effects PS-IgG IC on (B) polarization, (C) phagocytosis of Zymosan, and (D) intracellular ROS levels in THP-1 cell line with PMA treatment.

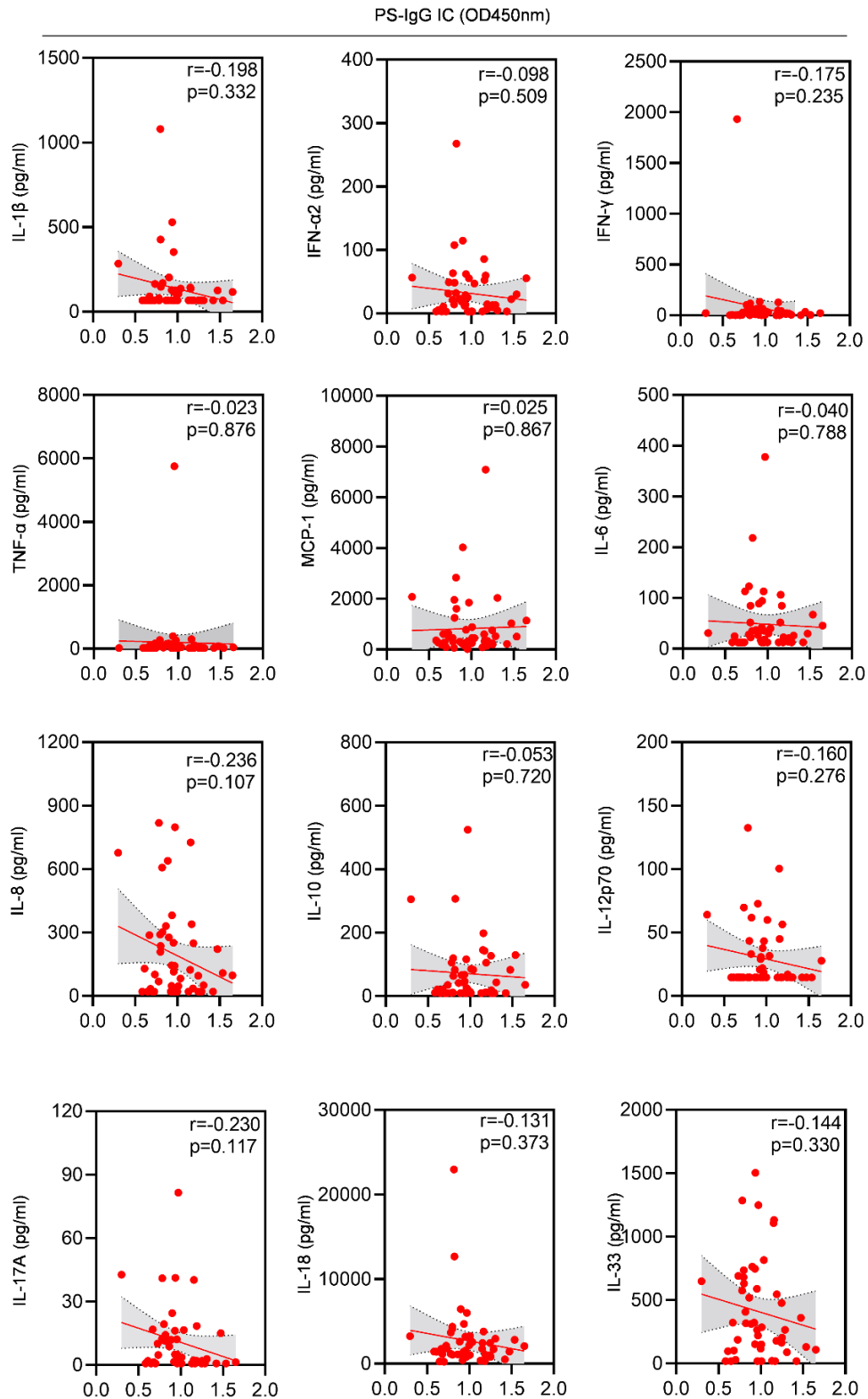


Figure S4. Correlation between serum PS-Ig G IC and cytokines in SLE patients.

Pearson correlation test was used to analyze the correlation between the serum cytokine levels and PS-IgG IC levels in patients with SLE (n = 48).

Table S4 Figure 1A-B

Anti-PS IgG		PS-IgG IC		Combined ROC of anti PS IgG and PS-IgG IC	
HC	SLE	HC	SLE	HC	SLE
0.3685	0.458	0.991	1.5365	0.75043	0.98657
0.368	0.4165	0.823	1.309	0.5962	0.94891
0.3695	0.493	0.7325	1.2855	0.5061	0.97326
0.3665	0.3625	0.664	0.5825	0.42707	0.33699
0.3765	0.4005	0.7965	1.246	0.59001	0.92383
0.381	0.3605	0.5625	0.6805	0.36027	0.42924
0.3605	0.4705	0.6905	1.1675	0.43956	0.94643
0.3895	0.3815	0.4905	0.959	0.31194	0.74979
0.3725	0.377	0.7045	0.9545	0.48425	0.73754
0.41	0.7175	0.826	1.6505	0.6955	0.99939
0.4005	0.36	0.7945	1.1305	0.64513	0.83223
0.362	0.3565	0.803	0.611	0.56097	0.35036
0.333	0.3445	0.8835	0.97	0.57222	0.68363
0.3525	0.37	0.602	0.999	0.33278	0.75945
0.3515	0.357	0.4145	1.188	0.18334	0.85972
0.337	0.3615	0.9015	0.299	0.60035	0.13256
0.351	0.57	0.784	1.151	0.51356	0.97825
0.329	0.3555	0.8395	1.0075	0.5164	0.73868
0.334	0.4085	0.8375	0.8235	0.52689	0.69004
0.3195	0.356	0.862	0.818	0.51609	0.56159
0.32	0.4095	0.9465	1.2515	0.60458	0.93147
0.3305	0.3885	0.828	1.421	0.5081	0.95731
0.372	0.409	0.7745	0.935	0.5563	0.78143
0.3475	0.3395	1.028	0.8015	0.73973	0.50295
0.4035	0.395	0.6245	1.4725	0.47836	0.96746
0.4255	0.3785	0.798	1.2465	0.70362	0.90685
	0.4465		1.183		0.93672
	0.57		0.7985		0.91087
	0.371		0.6495		0.42327
	0.341		0.6695		0.371
	0.3365		0.734		0.42502
	0.3245		0.7		0.36213
	0.3965		0.9665		0.78251
	0.419		1.0055		0.84174
	0.3725		0.726		0.50683
	0.3315		0.7955		0.47649
	0.515		0.778		0.84335
	0.38		0.9555		0.74415
	0.3525		0.9305		0.66489
	0.3465		0.92		0.64119
	0.309		0.8625		0.49014
	0.452		0.932		0.8449
	0.366		1.012		0.76205
	0.3245		0.782		0.44486
	0.3685		0.8865		0.65963
	0.317		1.156		0.78159
	0.409		1.0365		0.84562
	0.4745		0.8975		0.85534

Figure 2B-G

CD14+ macrophages (%)

PBS	PS	IgG	PS-IgG IC
7.33	7.4	8.5	0.95
7.74	3.46	11.3	1.46
9.52	9.67	14.2	2.98

Zymosan (%)

PBS	PS	IgG	PS-IgG IC
55.3	48.1	45.8	30.2
53.6	42.9	34.3	26.6
58.6	34.9	57.8	23.2

CD86+ M1 (%)

PBS	PS	IgG	PS-IgG IC
9.68	12.5	2.86	2.94
6.8	7.14	0	5.08
4.47	2.08	0	0.41

CD206+ M2 (%)

PBS	PS	IgG	PS-IgG IC
0	0	0	1.47
0.68	0	5.56	1.69
0.38	0.25	0.37	0

Figure 3A-H

DCF (%)

PBS	PS	IgG	PS-IgG IC
31.3	37.8	35.1	52.6
22.2	37	36.4	63.9
18.6	40.1	62.7	87.8

MitoSox (%)

PBS	PS	IgG	PS-IgG IC
63.7	64.9	67.1	66.2
67.1	63.5	52.1	54.7
69.9	67.1	47.1	43.9

MitoSpy (%)

PBS	PS	IgG	PS-IgG IC
42	45.5	47.4	47.1
78	72	64.8	56.7
80.6	81.1	68.4	75.5

DCF (%)

PS-IgG IC	PS-IgG IC+NAC
52.6	0.64
63.9	2.07
87.8	5.92
48.1	19.9

Zymosan (%)

PS-IgG IC	PS-IgG IC+NAC
15.6	30.1
21.6	34.3
28	49.6
21	32.5

Figure 4F-H

CD14+ macrophages (%)

PS-IgG IC	PS-IgG IC+BAPN
1.81	5.13
1.76	7.53
2.27	4.14
2.83	4.39

DCF (%)

PS-IgG IC	PS-IgG IC+BAPN
57.5	46.6
67.6	59.9
66.9	61.6

Zymosan (%)

PS-IgG IC	PS-IgG IC+BAPN
15.3	34.6
40.5	56.3
39.2	53

Figure 5A C-F

PS-IgG IC

Control	Lupus
0.735	1.074
0.4525	1.159
0.44	1.0275
0.58	1.2005
0.3955	0.8775
0.359	1.07
0.347	0.7375
0.1445	0.634
0.124	0.7695

Anti-PS IgG

Control	PS IM
0.2005	0.99
0.0335	0.4285
0.044	0.662
0.016	0.381
0.2265	0.624

PS-IgG IC

Control	PS IM
1.089	1.1945
0.6835	1.058
0.279	1.525
0.376	0.966
0.447	1.1655

Anti-dsDNA IgG

Control	PS IM
0.1775	0.6325
0.0745	0.2955
0.0905	0.4165
0.061	0.2315
0.1245	0.358

Serum creatinine

Control	PS IM
335.4523	586.9012
173.8066	369.5026
350.0453	462.6734
226.5659	533.0193
204.1151	386.3407

Figure 6B-G

CD11b⁺F4/80⁺ macrophages (%)

Bone marrow		Peritoneal cavity		Kidney	
Control	PS IM	Control	PS IM	Control	PS IM
24.4	27.2	54.9	44.8	41.9	55.5
28.6	29.8	65.3	45.4	41.6	45.5
17.2	20.4	61.4	43	44.4	51.8
16.4	16.8	52.4	34.8	45.1	46.4
13.8	23.5	52.5	44.8	38	56.6

DCF (%)

Bone marrow		Peritoneal cavity		Kidney	
Control	PS IM	Control	PS IM	Control	PS IM
0.54	0.23	1.67	14.4	3.84	82.6
0.12	0.65	0.26	19.3	4.99	59.8
0.24	0.22	4.05	13.2	14.1	34
0.11	0.14	2.63	15.8	18.1	40.6
0.12	0.81	11.7	11.1	10.1	49.7

Zymosan (%)

Control	PS IM	Zymosan (%)	
		PS IM	PS IM+NAC
7.14	4.22	6.39	12
11.3	1.56	7.32	12.5
11.1	2.55	2.27	6.74
7.39	3.81	1.79	8.08
8.7	3.06	1.57	11.7

DCF (%)

PS IM	PS IM+BAPN	Zymosan (%)	
		PS IM	PS IM+BAPN
32.6	25	3	1.97
24.9	25.6	1.86	7.73
32.8	17.8	2.73	11.4
36.5	26	1.45	10.7