Supplementary Table S1. Definition of 56 immune cell subsets in blood immunophenotyping.

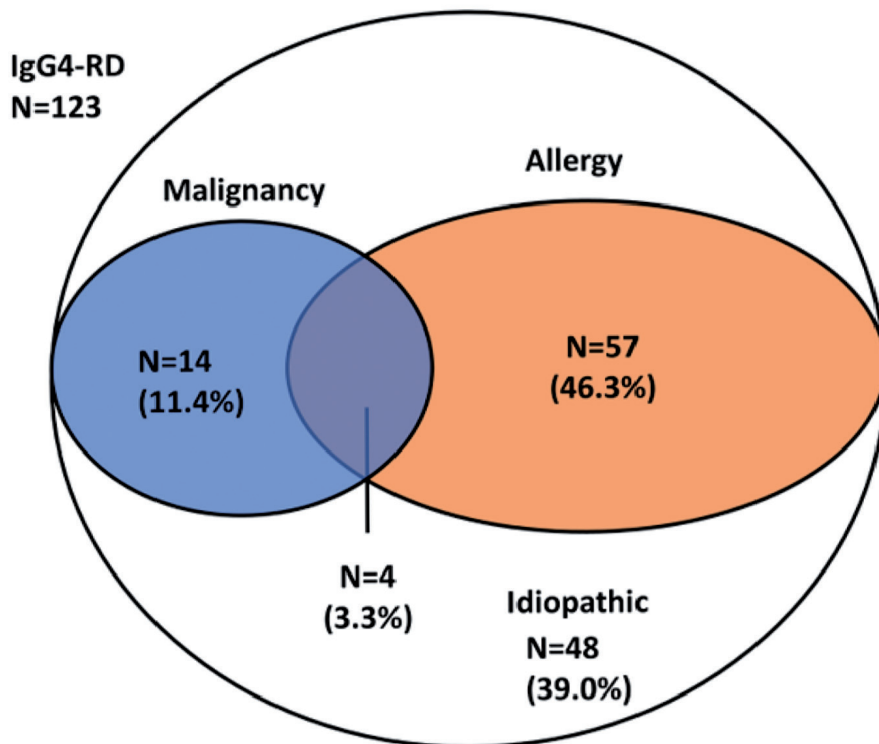| Immune cell subset	Definition	Immune cell subset	Definition	Immune cell subset	Definition	Immune cell subset	Definition
CD3+T cell	CD3+ lymphocytes	Treg	CD4+CD45RO+CCR4+CD127-CD25+CXCR5-HLA-DR-T cell	DNT	CD3+TCRαβ+CD4-CD8-lymphocyte	NK	CD3-CD19-CD20-CD14-HLA-DR-CD56+ lymphocyte
CD4+T cell	CD3+CD4+CD8-lymphocytes	Activated Treg	CD4+CD45RO+CCR4+CD127-CD25+CXCR5-HLA-DR+T cell	CXCR5-CD2+ DNT	CXCR5-CD2+DNT	DC	CD3-CD19-CD20-CD14-HLA-DR+CD56-lymphocyte
Activated CD4+T cell	HLA-DR+CD38+CD4+T cell	Naïve Tfh	CXCR5+CD45RA+CD4+T cell	CXCR5+CD2+ DNT	CXCR5+CD2+ DNT	mDC	CD11c+CD123-DC
Naïve CD4+ T cell	CCR7+CD45RA+CD4+T cell	Tfh	CXCR5+CD45RA-CD4+T cell	CXCR5+CD2-DNT	CXCR5+CD2-DNT	pDC	CD11c-CD123+DC
CD4+ Teff	CCR7-CD45RA+CD4+T cell	Tfh1	CXCR3+CCR6-Tfh	CXCR5-CD2-DNT	CXCR5-CD2-DNT	Monocytes	HLA-DR+CD14+CD3-CD19-CD56-lymphocyte
CD4+ Tcm	CCR7+CD45RA-CD4+T cell	Tfh2	CXCR3-CCR6-Tfh	γδT	CD3+CD56+γδTCR+ lymphocyte	CD14+CD16-monocyte	CD14+CD16-monocyte
CD4+ Tem	CCR7-CD45RA-CD4+T cell	Tfh17	CXCR3-CCR6+Tfh	NKT	CD3+CD56+γδTCR-lymphocyte	CD14+CD16+ monocyte	CD14+CD16+monocyte
Th1	CXCR3+CCR6-CD45RA-CD4+T cell	Tfh1-17	CXCR3+CCR6+Tfh	CD19+B cell	CD19+CD3-lymphocyte	CD14-CD16+ monocyte	CD14-CD16+monocyte
Activated Th1	HLA-DR+Th1	Tfr	CD4+CD45RO+CCR4+CD127-CD25+CXCR5+HLA-DR-T cell	Naïve B cell	IgD+CD27-CD19+B cell	Eosinophil	CD16-CCR3+granulocyte
Th2	CXCR3-CCR6-CD45RA-CD4+T cell	CD8+T cell	CD3+CD4-CD8+lymphocytes	IgD+ memory B cell	IgD+CD27+CD19+B cell	Neutrophil	CD16+CCR3-granulocyte
Activated Th2	HLA-DR+CCR4+Th2	Activated CD8+T cell	HLA-DR+CD38+CD8+T cell	Memory B cell	IgD-CD27+CD19+B cell	Basophil	CD3-CD19-CD20-CD14-HLA-DR-CD56-CD123+ lymphocyte
Th17	CXCR3-CCR6+CD45RA-CD4+T cell	Naïve CD8+T cell	CCR7+CD45RA+CD8+T cell	Plasmablast	CD20-CD138-memory B cell		
Activated Th17	HLA-DR+Th17	CD8+ Teff	CCR7-CD45RA+CD8+T cell	Plasma cell	CD20-CD138+memory B cell		
Th1-17	CXCR3+CCR6+CD45RA-CD4+T cell	CD8+ Tcm	CCR7+CD45RA-CD8+T cell	Other B cell	IgD-CD27-CD19+B cell		
Activated Th1-17	HLA-DR+Th1-17	CD8+ Tem	CCR7-CD45RA-CD8+T cell	Transitional B cell	CD38+CD24+CD19+B cell		

Supplementary Table S2. Antibodies used for flow cytometric analysis.

Fluorescentdye	T cell, T helper, T follicular helper cell	T regulatory, T follicular regulatory, double negative T cell	B cell	Dendritic cell, monocytes, natural killer cell, Basophil, Neutrophil
FITC	CD3	CD127	CD3	CD56
PE	CXCR3	CD25	-	NKG2D
PE-CF594	CCR7	CD3	HLA-DR	CCR3
PC5.5	HLA-DR	HLA-DR	CD19	CD123
PC7	CD45RA	CCR4	CD27	CD11c
APC	CD38		CD38	CD16
APC-Cy7	CD8	CD45RO	CD20	CD19, CD20
BV421	CXCR5	CXCR5	CD24	γδTCR
BV510	-	TCRαβ	IgD	HLA-DR
BV605	CCR4	CD2	CD138	CD14
BV711	CCR6	CD8	-	CD11b
BV786	CD4	CD4	-	CD3

Supplementary Table S3. Types of malignancy in IgG4-related disease.

Types of malignancy	Number
Gastric cancer	3
Colon cancer	2
Renal cell carcinoma	2
Hepatic cell carcinoma	2
Lung cancer	2
Malignant lymphoma	2
Pancreatic cancer	1
Prostate cancer	1
Bladder cancer	1
Esophageal cancer	1
Breast cancer	1
Epithelioid hemangioendothelioma	1
Unknown primary	1

Two patients had two malignancies (renal cell and hepatic cell carcinomas, gastric and bladder cancers).

Supplementary Fig. S1. Proportion of IgG4-RD according to the presence of malignancy and allergy. Among 123 patients, 18 (14.6%) were malignancy group, 57 (46.3%) were allergy group and 48 (39.0%) were idiopathic group, respectively.

Supplementary Table S4. Comparison of clinical characteristics of IgG4-RD between allergy except for asthma and asthma.

	Allergy except for asthma n=48	Asthma n=9	*p*-value
Age, years, mean (SD)	54.1 ± 13.2	56.4 ± 13.0	0.62
Male, n (%)	20 (41.6)	4 (44.4)	1.00
Smoking history, n (%)	22 (45.8)	2 (22.2)	0.28
Malignancy, n (%)	0 (0)	0 (0)	-
Atopic history, n (%)	48 (100)	9 (100)	-
Organ involvement, n (%)			
Pachymeninges	0 (0)	2 (22.2)	0.02
Orbits and lacrimal glands	39 (81.3)	6 (66.7)	0.38
Salivary glands	33 (68.8)	6 (66.7)	1.00
Lymph nodes	21 (43.8)	8 (88.9)	0.03
Lungs	14 (29.2)	5 (55.6))	0.14
Aorta and large blood vessels	3 (6.3)	1 (11.1)	0.51
Retroperitoneum	6 (12.5)	2 (22.2)	0.60
Pancreas	12 (25.0)	1 (11.1)	0.67
Bile duct and liver	0 (0)	0 (0)	-
Kidney	17 (35.4)	2 (22.2)	0.70
Skin	2 (4.2)	0 (0)	1.00
Number of organ involvements, mean (SD)	3.2 ± 1.7	3.9 ± 1.5	0.25
IgG4-RD RI, mean (SD)	12.1 ± 5.6	14.7 ± 4.6	0.22
Clinical phenotype of IgG4-RD, n (%)			
Head and neck limited	19 (39.6)	2 (22.2)	0.46
Systemic and Mikulicz	28 (58.3)	6 (66.7)	0.73
Retroperitoneum and aorta	1 (2.1)	1 (11.1)	0.29
Pancreato-hepato-biliary	0 (0)	0 (0)	-
Serological findings, mean (SD)			
IgG, mg/dL	1904 ± 982	2093 ± 924	0.59
IgG4, mg/dL	611 ± 586	892 ± 472	0.18
IgG4/IgG ratio	0.29 ± 0.16	0.49 ± 0.14	0.02
IgE, IU/mL	732 ± 801	760 ± 832	0.93
sIL-2R, mg/dL	770 ± 748	827 ± 329	0.84
CRP, mg/dL	0.24 ± 0.53	0.09 ± 0.10	0.40
Eosinophil count, /μL	357 ± 457	683 ± 475	0.06
Induction therapy, n (%)	n=37	n=7	0.30
GC alone	36 (97.3)	6 (85.7)	
GC + IVCY	0 (0)	0 (0)	
GC + RTX	1 (2.7)	1 (16.7)	
Initial dose of GC, mg/day, mean (SD)	36.8 ± 9.6	35.0 ± 8.7	0.66
Maintenance therapy, n (%)			0.10
GC alone	19 (51.4)	5 (83.3)	
GC + AZA	2 (5.4)	1 (16.7)	
GC + Tac	12 (32.4)	1 (16.7)	
GC + CyA	0 (0)	0 (0)	
GC + MTX	3 (8.1)	0 (0)	
GC + MMF	0 (0)	1 (16.7)	
GC + RTX	1 (2.7)	0 (0)	
Remission, n (%)	29 (78.4)	4 (57.1)	0.34

AZA: azathioprine; CyA: cyclosporin A, CRP: C-reactive protein; GC: glucocorticoid; Hb: haemoglobin; IgG4-RD: IgG4-related disease; IgG4-RD RI: IgG4-related disease-responder index; IVCY: intravenous cyclophosphamide, MMF: mycophenolate mofetil; PLT: platelet; sIL-2R: soluble interlukin-2 receptor; Tac: tacrolimus; RTªX: rituximab; SD: standard deviation; WBC: white blood cell

Supplementary Table S5. Binomial logistic regression analysis for malignancy in IgG4-RD.

Variables	OR	95% CI	*p*-value
Age	1.07	1.02-1.12	0.005
Sex (male)	5.50	1.50-20.1	0.01
Non-atopic history	4.16	1.28-13.5	0.02
Smoke	4.67	1.44-15.1	0.01
Orbit or lacrimal gland lesion	0.383	0.139-1.06	0.06
Aorta or large vessel lesion	3.25	1.050-10.1	0.04

Supplementary Table S6. Clinical characteristics of patients performed immunophenotyping.

	Malignancy n=5	Allergy n=10	Idiopathic n=10
Sex (male:female)	3:2	3:2	3:2
Age, mean ± SD	70.2±11.8	66.7±8.6	68.8±10.0
Serum IgG4, mg/dl, mean ± SD	495±290	477±252	525±323
Number of affected organs, mean ± SD	2.8±1.2	3.0±1.6	3.0±0.7