

Internal Organ Involvement in IgG4-related Sialadenitis: A Systemic Review

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Objective: To provide an overview of internal organ involvement (IOI) in immunoglobulin G4-related sialadenitis (IgG4-RS) patients, with a focus on the prevalence and clinical features of IOI, the analysis of serum IgG4 levels in patients with or without IOI, and the usefulness of positron emission tomography (PET) for examination of the whole body.

Methods: A systematic search was performed using PubMed, CNKI, Wanfang Data and CQVIP databases.

Results: A total of 99 articles, including 493 IgG4-RS cases, were analysed in this study. The male-to-female ratio was 1.57:1 and the mean age was 61.67 years. IOI was observed in 71.6% patients, including lesions of the pancreas (38.5%), the biliary system and liver (17.8%), distant lymphadenopathy (20.3%), the respiratory system (15.6%), the urinary system (12.0%) and retroperitoneal fibrosis (11.4%). The lesions could occur homeochronously or metachronously with IgG4-RS. The serum IgG4 levels in the IOI-positive and IOI-negative groups were $1,131 \pm 952$ mg/dL and 659 ± 843 mg/dL, respectively ($P < 0.01$). The prevalence of IOI and the number of involved internal organs between the PET and the non-PET groups showed no significant difference ($P = 0.399$ and $P = 0.823$, respectively), but were significantly higher in the PET group, amongst patients whose first symptom or chief complaint was salivary gland swelling ($P = 0.002$ and $P = 0.001$, respectively).

Conclusion: IOI is common in IgG4-RS and almost every organ can be affected. High levels of serum IgG4 represent a potential indicator of IOI. Furthermore, PET is a useful tool for evaluation of the whole body.

Key words: IgG4-RD, IgG4-RS, internal organ involvement, serum IgG4 level, PET

Immunoglobulin G4-related disease (IgG4-RD) is a systemic immune-mediated disease that has recently attracted attention in many areas of medicine. It is characterised by dense lymphoplasmacytic infiltrates, storiform fibrosis and elevated serum IgG4 levels¹. In 2001, Hamano et al first suggested a relationship between high serum IgG4 levels and sclerosing pancreatitis, but it was not until 2003 that Kamisawa et al identified extrapancreatic manifestations and classified it as a systemic disease^{2,3}. To date, more than 40 different organs have been reported to be involved in IgG4-RD, and salivary gland

involvement or IgG4-related sialadenitis (IgG4-RS), is amongst the most common types of lesions⁴.

IgG4-RS is characterised by the swelling of single or multiple salivary and/or lacrimal glands, with dysfunction of the involved glands^{5,6}. Previously, we showed that comorbid diseases of IgG4-RS in the head and neck were rather common (data not shown). The involvement of internal organs has also been reported in many clinical studies and case reports⁴. However, the prevalence of internal organ involvement (IOI) and its relationship with IgG4-RS has remained unclear. Furthermore, the relationship between serum IgG4 levels and IOI is not yet fully understood. Positron emission tomography (PET) is a good way to carry out evaluations of the whole body, but its application and usefulness in IgG4-RD patients has been rarely reported⁷⁻¹².

In this study, we collected and analysed all IgG4-RS patients reported in the English and Chinese literature

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Table 1 IOI of IgG4-RS and its prevalence.

Involved Organs	No. of cases	Prevalence (%)	References
IOI	353	71.6	7-105
AIP	190	38.5	7,8,10-12,14-18,20-28,32,33,37,39,41,44,46,48-52,57-60,62,64-66,69,71,76-78,80-84,88,91-93,95-103,105
Biliary system and liver involvement	88	17.8	8,11,12,14,16-18,20,21,23,24,27,32,46,48-52,55,60,62,65,66,68,69,71,77,78,83,91,95-97,100
Distant lymphadenopathy	100	20.3	8-11,14,18,19,23,24,26,27,29,34,35,37,43-45,48,52,53,55,58,63,64,66,67,70-73,75,77,80,84,86,88,93,94,96,98-102,104,105
Respiratory system involvement	77	15.6	7-10,12,15,18,24,26,33,37,44,46,49,52,58,60,62-65,67,69,70,72,73,78,81,84,88,91,93,94,96,99,101,102,104
Urinary system involvement	59	12.0	7-9,12,16,18,22,27,30,31,33,34,37,44,52,55,58,59,62,64,69,72,74,76-78,81,83,84,90,91,93,100,105
Retroperitoneal fibrosis	56	11.4	7,8,10,15,19,26,41,44,47-49,53,55,64,71,77,81,84,85,89,91,94
Prostate involvement	30	6.1	7,8,11,21,24,50,52,65,69,76,84,88,90,91,101
Cardiovascular involvement	28	5.7	7-9,11,41,52,57,58,60,65,66,70,74,84,86
Hypophysitis	9	1.8	7,10,12,19,26,46,64,65,74
Meninges involvement	7	1.4	10,38,63,65,74,91
Gastrointestinal tract involvement	4	0.8	25,75,91
Spleen involvement	3	0.6	8,9,24
Breast involvement	3	0.6	7,65

IOI: Internal organ involvement
AIP: Autoimmune pancreatitis

three internal organs in 60 cases (14.6%), four internal organs in 25 cases (6.1%) and five or more internal organ lesions in 11 cases (2.7%) (Fig 2).

Autoimmune pancreatitis (AIP)

AIP was the most common lesion that was reported for 190 IgG4-RS patients with a prevalence of 38.5%. The symptoms related to pancreatitis were the chief complaint for 70 of 107 patients, while the chief complaint of the other 83 patients was not clear. The main symptoms were jaundice in 21 patients, abdominal pain in eight patients, and weight loss or loss of appetite in six patients. Additionally, 44 patients with no symptoms were found to have AIP during subsequent examinations. The course of disease was clearly reported in 74 patients. This included 17 patients who suffered AIP prior to swelling of the salivary glands with the longest

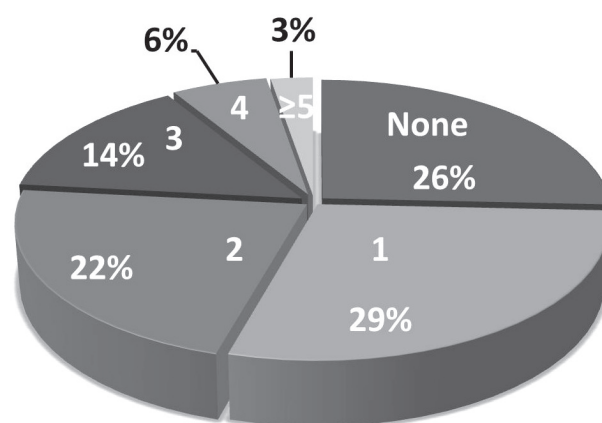


Fig 2 The number of involved internal organs in IgG4-RS patients. IOI was detected in 74.3% of patients. Specifically, one IOI lesion in 28.6% of cases; two IOI lesions in 22.3% of cases; three IOI lesions in 14.6% of cases; four IOI lesions in 6.1% of cases; and five or more IOI lesions in 2.7% of cases were detected.

time interval being 10 years. Additionally, 38 patients were found to have AIP and IgG4-RS almost simultaneously and another 19 patients turned to doctors because of AIP, following the appearance of salivary gland swelling, with the longest time interval being 15 years. The main radiological characteristics of AIP were occupying lesions in 13 patients, localised or diffuse swelling of the pancreas in 46 patients and an abnormality of the pancreatic ducts in 12 patients.

Biliary system and liver involvement

Biliary system and liver involvement was reported in 88 cases (17.8%), including 78 cases that were combined with AIP. A total of 12 patients were found to have biliary system and liver involvement at the first visit. Based on the detailed medical history of 17 patients, biliary system and liver involvement occurred prior to IgG4-RS in two patients, at the same time in eight cases, and after enlargement of the salivary glands in seven patients with the longest time interval being 2 years. Based on endoscopic retrograde cholangiopancreatography (ERCP) or other radiological examinations, involvement of the bile duct or sclerosing cholangitis, was the most common lesion, which could be observed in 71 patients. Other lesions, including involvement of the gall bladder ($n = 6$) and liver ($n = 7$), were also reported.

Distant lymphadenopathy

Distant lymphadenopathy was fairly common and reported in 100 patients (20.3%). Swelling of the axillary, hilar/mediastinal, abdominal and inguinal lymph nodes was observed in 15, 74, 15, and 13 patients, respectively. There were 46 patients who were found to have distant lymphadenopathy at the first visit. A study of 46 patients, who were able to provide a detailed medical history, showed that distant lymphadenopathy could present prior to ($n = 6$), concurrent with ($n = 23$) or after ($n = 17$) the appearance of IgG4-RS.

Respiratory system involvement

Lesions of the lungs and bronchi affected 77 IgG4-RS patients (15.6%); this was the chief complaint of 13 patients, with the symptom of cough exhibited in 10 patients and dyspnea observed in eight cases. An investigation of 21 IgG4-RS patients with a clear medical history showed that lung involvement occurred prior to, concurrent with, or after salivary gland swelling in two, eight and 11 patients, respectively. The lung manifestations could be masses or inflammatory pseudotumours

($n = 15$), interstitial pneumonia or consolidation ($n = 19$), or multiple nodules ($n = 2$). Bronchi involvement was observed in eight patients that manifested as thickness of the bronchi walls or abnormal intake values in PET. Thickness of the pleura occurred in nine patients and was combined with pleural effusion in one patient.

Urinary system involvement

The involvement of the urinary system occurred in 59 cases (12.0%); this was the chief complaint of four patients and was observed on the first visit in 10 patients. There were two out of 20 cases who reported urinary system involvement prior to IgG4-RS, eight cases that occurred homeochronously, and 10 cases that showed an abnormality of the urinary system after salivary gland swelling, with the longest time interval being 8 years. Interstitial nephritis was the most common lesion, which affected 11 patients, including four who also suffered from chronic renal failure. There were six patients with occupying lesions of the kidney. Increased thickness of the pelvis, ureter, or bladder was observed in five patients.

Retroperitoneal fibrosis

Retroperitoneal fibrosis was observed in 56 cases (11.4%) and was recorded as the chief complaint in five patients. Retroperitoneal masses were located around the pelvis or ureter in 10 patients, and around the abdominal aorta or iliac artery in eight patients. Different degrees of secondary hydronephrosis were observed in 10 cases.

Involvement of other organs

The involvement of the prostate was observed in 30 patients. Cardiovascular involvement occurred in 28 patients. Specifically, 28 patients showed complications of periaortitis, including two patients with perivascular soft tissue of the coronary artery, seven patients who were reported to have pericardium involvement, and pericardial effusion in one patient. Another patient was reported to have multiple aneurysms and died of an aneurysm rupture with a pathological confirmation of IgG4-related disease. Furthermore, nine IgG4-RS patients also suffered hypophysitis. Involvement of other organs, including the meninges, gastrointestinal tract, spleen, and breast, were occasionally reported in seven, four, three and three patients, respectively.

Serum IgG4 levels

The serum levels of IgG4 were reported at the time of diagnosis in 383 cases, including in 250 cases for which individual patient values were available and in the form of mean \pm standard deviation in two studies that contained 133 cases. Elevated levels of serum IgG4 were observed in 372 patients (97.4%). We divided patients into groups based on the presence or absence of IOI, and compared levels of serum IgG4 between the two groups. The IOI-positive group included 286 patients (74.7%), while the IOI-negative group included 97 patients (25.3%). The mean levels of serum IgG in the IOI-positive group ($1,131 \pm 952$ mg/dL) were much higher than those in the IOI-negative group (659 ± 843 mg/dL; $P < 0.01$). A comparison of the 220 IOI-positive cases with precisely reported serum IgG4 levels also revealed that the mean serum IgG4 levels of the 71 individuals with three or more IOI lesions ($1,509 \pm 1,166$ mg/dL) were much higher than those in the 149 cases with only one or two IOI lesions ($1,094 \pm 899$ mg/dL, $P < 0.01$).

Evaluation of PET

PET was performed in 145 cases which were described in 22 articles. After excluding papers that did not describe whether PET was performed in each individual or the detailed condition of IOI, we included 390 cases and divided them into the PET group or the non-PET group based on whether the patient received a PET examination. We found that PET was performed in 132 patients (33.8%). No significant difference was observed between the groups for the prevalence of IOI ($P = 0.399$) and involved internal organs ($P = 0.823$). A comparison of different involved organs revealed that the detection rate of retroperitoneal fibrosis, prostate involvement and cardiovascular involvement in the PET group were significantly higher than those of the non-PET group ($P = 0.003$, $P < 0.001$ and $P = 0.002$, respectively). However, the detection rate of AIP, biliary system and liver involvement, and distant lymphadenopathy in the PET group were significantly lower than those of the non-PET group ($P = 0.002$, $P = 0.002$ and $P = 0.007$, respectively). The detection rates of respiratory and urinary system involvement of the two groups were not significantly different ($P = 0.543$ and $P = 0.074$, respectively). Further analysis of the 130 cases with clear descriptions of the first symptom or chief complaint being swelling of the salivary glands showed that PET was performed in 36 patients (27.7%). Unlike the aforementioned results, the prevalence of IOI and the number of involved internal organs were significantly

higher in the PET group than in the non-PET group ($P = 0.002$ and $P = 0.001$, respectively). A comparison of the different involved organs showed that the detection rate of retroperitoneal fibrosis, prostate involvement, cardiovascular involvement, and respiratory system involvement in the PET group were all significantly higher than those in the non-PET group ($P = 0.007$, $P = 0.001$, $P < 0.001$ and $P < 0.001$, respectively). No significant difference was observed for the detection rate of AIP, biliary system and liver involvement, distant lymphadenopathy, or urinary system involvement ($P = 0.156$, $P = 0.181$, $P = 0.363$, and $P = 0.403$, respectively). Detailed results are listed in Table 2.

Discussion

IgG4-RS is a newly recognised autoimmune disease that mostly affects Asian individuals, especially those of Japanese descent⁴. Its pathogenesis is unclear, and to the best of our knowledge, this phenomenon may be associated with the initial identification of IgG4-RD in Japan. The epidemiological features of IgG4-RS have not yet been definitively described. However, according to a nationwide survey conducted in Japan, there are approximately 8000 patients with IgG4-RD and about 4300 patients with IgG4-RS¹⁰⁶. Unlike Sjögren syndrome, male patients are more frequently affected than female patients^{107,108}. The mean age at diagnosis was 61.67 years, and ranged from 11 to 89 years old^{43,61}.

The features of IgG-RS have been studied in detail and, to avoid unnecessary invasive treatments, it is important for oral and maxillofacial surgeons to distinguish this disease from tumours and other inflammatory diseases^{69,109,110}. It is also important to consider this systemic disease from the perspective of the whole body. According to our study, IOI occurred in 71.6% of patients, which represents nearly three quarters of IgG4-RS patients combined with IOI, although they can sometimes be asymptomatic. So, once a diagnosis of IgG4-RS is made, it is necessary to perform an evaluation of the whole body to obtain a full view of the general condition of the patient. Moreover, histories of AIP, sclerosing cholangitis, interstitial pneumonia, interstitial nephritis, and retroperitoneal fibrosis are all potential indicators of this systemic disease when patients arrive at the clinic, presenting for salivary gland swelling alone.

AIP has been regarded as the most common lesion of IgG4-RD^{2,106}. It is also the most common IOI in IgG4-RS patients, occurring in 38.5% of cases according to our study. This can occur either homeochronously or metachronously with IgG4-RS. Its symptoms include

Table 2 Detection rate of IOI in the PET and the non-PET groups.

	Without concern for the first symptom or chief complaint (n = 390)			Concerning salivary glands swelling as the first symptom or chief complaint (n = 130)		
	PET group (n = 132) (%)	Non-PET group (n = 258) (%)	P-value	PET group (n = 36) (%)	Non-PET group (n = 94) (%)	P-value
IOI	98 (74.2)	196 (76.0)	0.399	30 (83.3)	52 (55.3)	0.002
AIP	43 (32.6)	125 (48.4)	0.002	18 (50.0)	36 (38.3)	0.156
Biliary system and liver involvement	15 (11.4)	61 (23.6)	0.002	11 (30.6)	20 (21.3)	0.181
Distant lymphadenopathy	21 (15.9)	71 (27.5)	0.007	10 (27.8)	31 (33.0)	0.363
Respiratory system involvement	29 (22.0)	57 (22.1)	0.543	16 (44.4)	5 (5.3)	< 0.001
Urinary system involvement	9 (6.8)	31 (12.0)	0.074	5 (13.9)	10 (10.6)	0.403
Retroperitoneal fibrosis	27 (20.5)	25 (9.7)	0.003	10 (27.8)	8 (8.5)	0.007
Prostate involvement	18 (13.6)	9 (3.5)	< 0.001	7 (19.4)	1 (1.1)	0.001
Cardiovascular Involvement	17 (12.9)	11 (4.3)	0.002	10 (27.8)	1 (1.1)	< 0.001

IOI: Internal organ involvement; AIP: Autoimmune pancreatitis

jaundice, abdominal pain, weight loss, and anorexia in the IgG4-RS cases that were included. Other symptoms, such as pruritus and steatorrhea, were also reported in AIP studies¹¹¹. Ultrasonography, computed tomography (CT), magnetic resonance (MR), PET and ERCP can all be used for the diagnosis and evaluation of AIP¹¹². Importantly, pancreatic cancer should be differentiated when the lesion appears as a mass¹¹². Involvement of the biliary system and liver is also frequently observed in IgG4-RD and often occurs along with AIP¹¹³. Sclerosing cholangitis, which can manifest with increased thickness of the bile duct wall, stenosis of the duct, and dilatation of the distal or intrahepatic bile duct, is the most common lesion²³.

Lymphadenopathy is common in IgG4-RS patients. Previously, we have shown that almost 80% of cases occurred simultaneously with cervical lymphadenopathy (data not shown). However, distant lymphadenopathy can also be observed and was observed in 20.3% of cases in our study. Its actual prevalence could be higher because of the low detection rate using a chest radiograph. Lymph nodes of the hilum and mediastinum were the most frequently affected^{23,58}. Diseases such as lymphoma and sarcoidosis should be excluded during diagnosis.

Involvement of the respiratory and urinary systems can often be observed in IgG4-RD patients and, in our

study of IgG4-RS cases, the prevalence was 15.2% and 8.7%, respectively. Interstitial tissue involvement of the lung or kidney is the most common lesion, which can potentially cause respiratory or renal failure^{26,27}. A inflammatory pseudotumour is another common lesion that should be differentiated from malignant tumours. When involvement of the respiratory or urinary tract occurs, it sometimes appears as increased tract wall thickness^{31,64}.

Retroperitoneal fibrosis is a periaortic sclerotic disease that encases adjacent retroperitoneal structures, particularly the ureters, and this could cause obstruction of the urinary tracts along with secondary hydronephrosis¹¹⁴. Cardiovascular involvement occasionally occurs and could potentially cause sudden death, or a condition in which surgical intervention may be necessary⁶⁰.

Based on an analysis of the clinical course of IgG4-RS patients, we concluded that all IOI lesions can either precede, coexist with, or follow swelling of the salivary glands. The time interval between IgG4-RS and IOI could be as long as 10 years, or potentially greater²³. Therefore it is assumed that the longer the medical history is, the greater the chance of IOI. A retrospective study of the natural clinical history and histopathological characteristics of IgG4-RS showed that the amount of salivary secretion decreased along with histological changes and delayed therapeutic intervention¹¹⁵.

Therefore, we suggest that early intervention is needed to avoid further IOI and to improve outcomes in IgG4-RS patients.

Based on the comprehensive diagnosis criteria for IgG4-RD published by Umehara et al, elevated serum IgG4 levels is an important, but not a prerequisite criterion for IgG4-RD¹¹⁶. Although some IgG4-RD patients were found to have normal serum IgG4 levels, several studies also reported higher serum IgG4 levels in the multiple organ involvement group compared with those in the single organ involvement group^{7,113}. In this present study, we compared serum IgG4 levels in the IOI-positive and IOI-negative groups and obtained results that were consistent with those of previous studies, suggesting that serum IgG4 level is a potential predictor of IOI. The serum IgG4 levels of patients with three or more IOI lesions were also higher than those with one or two IOI lesions. Although no clear conclusion has been reached concerning whether serum IgG4 levels reflect the activity of IgG4-RS, we could at least presume that the higher the IgG4 level is, the more probable that a patient suffers from IOI and therefore more attention should be paid to monitoring IOI.

Irrespective of economic factors, PET is a good way to acquire images of the whole body and obtain functional information about disease activity¹¹⁷. A prospective cohort study carried out in 35 patients with IgG4-RD showed that 71.4% of patients were found with more organ involvement by PET than by conventional evaluations, including physical examination, ultrasonography, and CT, especially in arteries and lymph nodes⁸. It is also a useful tool to evaluate the response of a patient to steroid therapy¹¹. In our present study, although no significant differences with regard to the prevalence of IOI and the overall number of involved internal organs were observed between the PET and the non-PET groups, PET was able to detect more IOI lesions than traditional methods regarding the enlargement of salivary glands as the first symptom or chief complaint. One probable reason is that the degree of IOI might be minimal and relatively difficult to detect in patients whose first symptom or chief complaint is salivary gland swelling, while patients with obvious internal organ dysfunctions were easier to identify with IOI, even by some traditional methods that have lower sensitivity. Our results also suggested the great advantages of PET in detecting retroperitoneal fibrosis, prostate involvement and cardiovascular involvement, most of which were asymptomatic. Considering all of our results, we suggest that PET has a higher sensitivity for detecting asymptomatic or early-stage lesions com-

pared with traditional methods. However, the possibility of false-negative evaluation results of small-sized lesions and brain or kidney contiguous lesions, should be considered^{10,12}.

Conclusions

IgG4-RS is a systemic disease and IOI is frequently reported. Almost any organ could be affected by IgG4-RS and the involvement of the pancreas, biliary system and liver, respiratory system and urinary system, as well as retroperitoneal fibrosis and distant lymphadenopathy are common. All IOI lesions can occur homeochronously or metachronously with IgG4-RS and early intervention is necessary. A high level of serum IgG4 is a potential indicator of IOI. PET potentially has a higher sensitivity for detecting asymptomatic or early-stage lesions compared with traditional methods and represents a useful tool for evaluations of the whole body.

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