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Distinguishing Takayasu Arteritis and Giant Cell Arteritis Based on Large-Vessel Involvement Patterns

Oh Chan Kwon[1*], Jang Woo Ha[2*], Min-Chan Park[1], Yong-Beom Park[3,4], and Sang-Won Lee[3,4]

[1]Division of Rheumatology, Department of Internal Medicine, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul;
[2]Division of Rheumatology, Department of Internal Medicine, Yongin Severance Hospital, Yonsei University College of Medicine, Yongin;
[3]Division of Rheumatology, Department of Internal Medicine, Severance Hospital, Yonsei University College of Medicine, Seoul;
[4]Institute for Immunology and Immunological Diseases, Yonsei University College of Medicine, Seoul, Korea.

Purpose: Takayasu arteritis (TAK) and extracranial large-vessel (LV) giant cell arteritis (GCA) share overlapping features, making differential diagnosis between the two diseases challenging. We aimed to identify LV involvement patterns that could accurately differentiate TAK and GCA.

Materials and Methods: This retrospective cohort study included 181 patients (TAK, n=175; GCA, n=6). LV involvement patterns were assessed using computed tomography (CT) and/or ^{18}F-fluorodeoxyglucose positron emission tomography/CT performed at diagnosis. A multivariable logistic regression model was used to identify LV involvement patterns that accurately distinguish TAK and GCA. Area under the curve (AUC) was estimated to determine the accuracy.

Results: The right subclavian artery (30.3% vs. 83.3%, p=0.013), aortic arch (13.7% vs. 83.3%, p<0.001), descending aorta (30.3% vs. 100.0%, p=0.001), and abdominal aorta (30.9% vs. 83.3%, p=0.015) were less commonly involved in TAK than in GCA. When categorized according to Hata's classification and clusters, type V (31.4% vs. 83.3%, p=0.016) and cluster 5 (2.3% vs. 83.3%, p<0.001) were less common in TAK than in GCA. Type V demonstrated an AUC of 0.760, whereas cluster 5 showed higher accuracy (AUC=0.905) in distinguishing TAK and GCA. A combination of right subclavian artery and aortic arch involvement (2.358 × right subclavian artery involvement+3.385×aortic arch involvement; cut-off=2.872), derived from the multivariable logistic regression model, yielded the highest accuracy (AUC=0.925).

Conclusion: Distinct patterns of LV involvement, particularly aortic arch involvement, either alone or combined with right subclavian artery involvement, could accurately differentiate TAK and GCA.

Key Words: Takayasu arteritis, giant cell arteritis, differential diagnosis, large vessels

INTRODUCTION

Takayasu arteritis (TAK) is a large-vessel vasculitis (LVV) that causes granulomatous inflammation primarily in the aorta and its main branches.[1] According to Hata's classification, TAK can be classified into six types (type I, IIA, IIB, III, IV, and V) based on the pattern of arterial involvement (Table 1).[2] An observational study from Japan reported that the most common type was type I (28.0%), followed by type V (25.8%).[3]

Giant cell arteritis (GCA) is another LVV characterized by granulomatous inflammation of the temporal artery, which was originally referred to as temporal arteritis when first described a century ago.[4] Although first recognized as a temporal artery disease, the advent of advanced imaging studies has revealed that extracranial large-vessels (LVs) are frequently involved in GCA, with a prevalence ranging from 20% to 83%.[5,6] Reflecting these updates, the nomenclature has evolved, and GCA is classified as LV-GCA, cranial GCA, and LV-GCA with cranial involvement according to the vessels affected.[7]

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Corresponding author: Sang-Won Lee, MD, PhD, Division of Rheumatology, Department of Internal Medicine, Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea.
E-mail: sangwonlee@yuhs.ac

*Oh Chan Kwon and Jang Woo Ha contributed equally to this work.
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Given that a substantial proportion of patients with GCA have extracranial LV involvement, differentiating LV-GCA from TAK can be challenging. Considering that LV biopsy is difficult and the pathology is indistinguishable between the two diseases,[8,9] understanding differences in LV involvement patterns between the TAK and GCA is important to differentiate the two diseases. Studies have compared LV involvement patterns between TAK and GCA and reported that mesenteric disease is more common in TAK, whereas axillary disease is more common in GCA.[10-13] Moreover, a study using an unsupervised computer-driven approach has shown divergent vascular involvement patterns between TAK and GCA.[14] In the study, six distinct clusters were identified (Table 1). Clusters 1, 2, and 3 were more common in TAK, whereas clusters 4, 5, and 6 were more common in GCA.[14] However, the accuracy of differentiating TAK from GCA using these clusters has not been tested. In addition, no study has applied Hata's classification to GCA, and its accuracy in differentiating TAK from GCA remains unknown. Based on this, using a cohort of patients with TAK and GCA, we tested the accuracy of Hata's classification and clusters in differentiating TAK from GCA. We also aimed to identify LV involvement patterns that could more accurately differentiate TAK and GCA.

MATERIALS AND METHODS

Study cohort

In this retrospective cohort study, we initially screened 175 patients with TAK and 9 patients with GCA who met the 2022 American College of Rheumatology/European Alliance of Associations for Rheumatology classification criteria for TAK[15] and GCA.[16] As the purpose of our study was to evaluate the accuracy of differentiating TAK and GCA according to LV involvement patterns, patients with cranial GCA (i.e., patients with cranial artery involvement only; n=3) were excluded. The remaining 181 patients (TAK, n=175; GCA, n=6) comprised the study cohort. This study was approved by the institutional review board (IRB) of Severance Hospital (Seoul, Korea, IRB No. 4–2022-1075) and was conducted in accordance with the Declaration of Helsinki. Given the retrospective design of the study, the requirement for written informed consent was waived by the IRB.

Table 1. Hata's Classification- and Cluster-Based LV Involvement Pattern

Hata's classification	
Type I	Branches of the aortic arch
Type IIA	Ascending aorta, aortic arch, and its branches
Type IIB	Ascending aorta, aortic arch with its branches, and thoracic descending aorta
Type III	Descending aorta, abdominal aorta and/or renal arteries
Type IV	Abdominal aorta and/or renal arteries
Type V	Combined features of type IIB and type IV
Cluster	
Cluster 1	Abdominal aorta, renal, and mesenteric arteries
Cluster 2	Bilateral involvement of the carotid and subclavian arteries
Cluster 3	Isolated involvement of the left subclavian artery
Cluster 4	Low burden of disease in the large arteries
Cluster 5	Aorta and the aortic arch branches
Cluster 6	Bilateral axillary and subclavian arteries

LV, large-vessel.

LV involvement patterns

The LV involvement patterns were assessed using computed tomography (CT) and/or ^{18}F-fluorodeoxyglucose positron emission tomography/CT performed at diagnosis. Involvement of the following 14 territories was evaluated: right carotid, left carotid, right subclavian, left subclavian, right axillary, left axillary, brachiocephalic, ascending aorta, aortic arch, descending aorta, abdominal aorta, mesenteric, right renal, and left renal arteries. Patients were categorized according to Hata's classification and clusters.

Statistical analysis

Continuous and categorical variables were expressed as median (interquartile range) and number (%), respectively. Demographics and LV involvement patterns were compared between patients with TAK and those with GCA. Mann–Whitney U test was used to compare continuous variables and Fisher's exact test was used to compare categorical variables. The distribution of patients according to Hata's classification and clusters was visualized using histograms. To test the accuracy of Hata's classification and clusters in differentiating TAK and GCA, receiver operating characteristic (ROC) curve analysis was performed, and the area under the curve (AUC) was estimated. For Hata's classification and clusters, multivariable logistic regression analysis with a backward elimination method was used to identify possible combinations of covariates that best distinguish TAK and GCA. Covariates that showed statistically significant differences between TAK and GCA were included in the multivariable model. Covariates with a p-value of > 0.1 were eliminated in each step, and the possible combination of covariates was determined based on the final step. Next, to identify LV involvement patterns that could more accurately distinguish TAK and GCA, an additional multivariable model was conducted. Vessel territories that showed statistically significant differences in involvement between TAK and GCA were included as covariates in the multivariable model. An equation was derived using the covariates remaining in the final step of the multivariable model. The covariates were multiplied by their β coefficients, and then summed. To evaluate the stability of the logistic regression model, bootstrap resampling (1000 iterations) was performed. The accuracy of this equation in differentiating TAK and GCA was assessed using the AUC. The optimal cut-off value for differentiating TAK and GCA was determined as the point at which Youden's index was maximized.

A *p*-value of <0.05 was considered statistically significant. All analyses were performed using SPSS software version 28.0 (IBM Corporation, Armonk, NY, USA).

RESULTS

Comparison of LV involvement patterns between TAK and GCA

The comparison between TAK and GCA is shown in Table 2. Patients with TAK were younger than those with GCA [45.0 (32.0–55.0) years vs. 62.5 (58.8–72.8) years, $p<0.001$], and both groups showed female predominance (86.9% vs. 83.3%, $p=0.580$). Regarding LV involvement, the right subclavian artery (30.3% vs. 83.3%, $p=0.013$), aortic arch (13.7% vs. 83.3%, $p<0.001$), descending aorta (30.3% vs. 100.0%, $p=0.001$), and abdominal aorta (30.9% vs. 83.3%,$p=0.015$) were less commonly involved in TAK than in GCA. In terms of Hata's classification, type V (31.4% vs. 83.3%, $p=0.016$) was less frequent in TAK than in GCA. The distribution of patients with TAK and those with GCA according to Hata's classification is shown in Fig. 1A and B, respectively. For the clusters, cluster 2 was more frequent (45.7% vs. 0.0%, $p=0.035$), whereas cluster 5 was less frequent (2.3% vs. 83.3%, $p<0.001$) in TAK than in GCA. The distribution of patients with TAK and GCA according to the clusters is shown in Fig. 1C and D, respectively.

Accuracy of Hata's classification and clusters in distinguishing TAK and GCA

With regard to Hata's classification, as only type V showed a statistically significant difference between TAK and GCA, type V was tested as a single covariate for accuracy in distinguishing TAK and GCA. The results of the ROC analysis are shown in Fig. 2A. Hata's classification type V showed accuracy in differentiating GCA from TAK [AUC=0.760, 95% confidence interval (CI)=0.579–0.940, $p=0.031$].

Regarding the clusters, clusters 2 and 5 showed statistically significant differences between TAK and GCA and were included in the multivariable model. Cluster 2 was eliminated in the first step, and only cluster 5 remained in the final step (i.e., no combination of covariates yielding higher accuracy was identified) (Table 3). Therefore, cluster 5 was tested as a single covariate for accuracy in distinguishing TAK and GCA. Cluster 5 was accurate (Fig. 2B: AUC=0.905, 95% CI=0.729–1.000, $p=0.001$) in differentiating GCA from TAK, with an AUC higher than that of Hata's classification type V.

LV involvement pattern that accurately differentiates TAK and GCA

Among the 14 territories, involvement of right subclavian artery, aortic arch, ascending aorta, and abdominal aorta differed significantly between TAK and GCA, and these covariates were included in the multivariable model. The right subclavian artery and aortic arch remained statistically significant in the final step (Table 3). The bootstrap results confirmed the statistical significance and stability of both covariates, with non-zero 95% CIs for the β coefficients of the right subclavian artery (β coefficient=2.358, 95% CI=0.180–19.267, $p=0.025$) and aortic arch (β coefficient=3.385, 95% CI=1.486–20.222, $p=0.001$). Using the β coefficient of each covariate, the following equation was developed: 2.358×right subclavian artery involvement (yes=1; no=0)+3.385×aortic arch involvement (yes=1; no=0). This equation was accurate in distinguishing TAK and GCA (Fig. 2C: AUC=0.925, 95% CI=0.845–1.000, $p<0.001$), with an AUC higher than that of Hata's classification type V and cluster 5. The cut-off value for the equation that best distinguished TAK and GCA was 2.872.

Table 2. Patient Demographics and LV Involvement Pattern

	TAK (n=175)	GCA (n=6)	*p*
Demographics			
Age (yr)	45.0 (32.0–55.0)	62.5 (58.8–72.8)	<0.001
Female	152 (86.9)	5 (83.3)	0.580
LV involvement			
Right carotid	59 (33.7)	4 (66.7)	0.185
Left carotid	89 (50.9)	4 (66.7)	0.683
Right subclavian	53 (30.3)	5 (83.3)	0.013
Left subclavian	95 (54.3)	5 (83.3)	0.227
Right axillary	1 (0.6)	1 (16.7)	0.065
Left axillary	3 (1.7)	1 (16.7)	0.127
Brachiocephalic	14 (8.0)	1 (16.7)	0.409
Ascending aorta	21 (12.0)	2 (33.3)	0.169
Aortic arch	24 (13.7)	5 (83.3)	<0.001
Descending aorta	53 (30.3)	6 (100)	0.001
Abdominal aorta	54 (30.9)	5 (83.3)	0.015
Mesenteric artery	18 (10.3)	0 (0.0)	>0.999
Right renal artery	21 (12.0)	0 (0.0)	>0.999
Left renal artery	32 (18.3)	0 (0.0)	0.593
Hata's classification			
Type I	59 (33.7)	0 (0.0)	0.179
Type IIA	8 (4.6)	0 (0.0)	>0.999
Type IIB	28 (16.0)	1 (16.7)	>0.999
Type III	5 (2.9)	0 (0.0)	>0.999
Type IV	20 (11.4)	0 (0.0)	>0.999
Type V	55 (31.4)	5 (83.3)	0.016
Cluster			
Cluster 1	40 (22.9)	0 (0.0)	0.341
Cluster 2	80 (45.7)	0 (0.0)	0.035
Cluster 3	21 (12.0)	0 (0.0)	>0.999
Cluster 4	25 (14.3)	1 (16.7)	>0.999
Cluster 5	4 (2.3)	5 (83.3)	<0.001
Cluster 6	5 (2.9)	0 (0.0)	>0.999

GCA, giant cell arteritis; LV, large-vessel; TAK, Takayasu arteritis.
Data are presented as median (interquartile range) or n (%).

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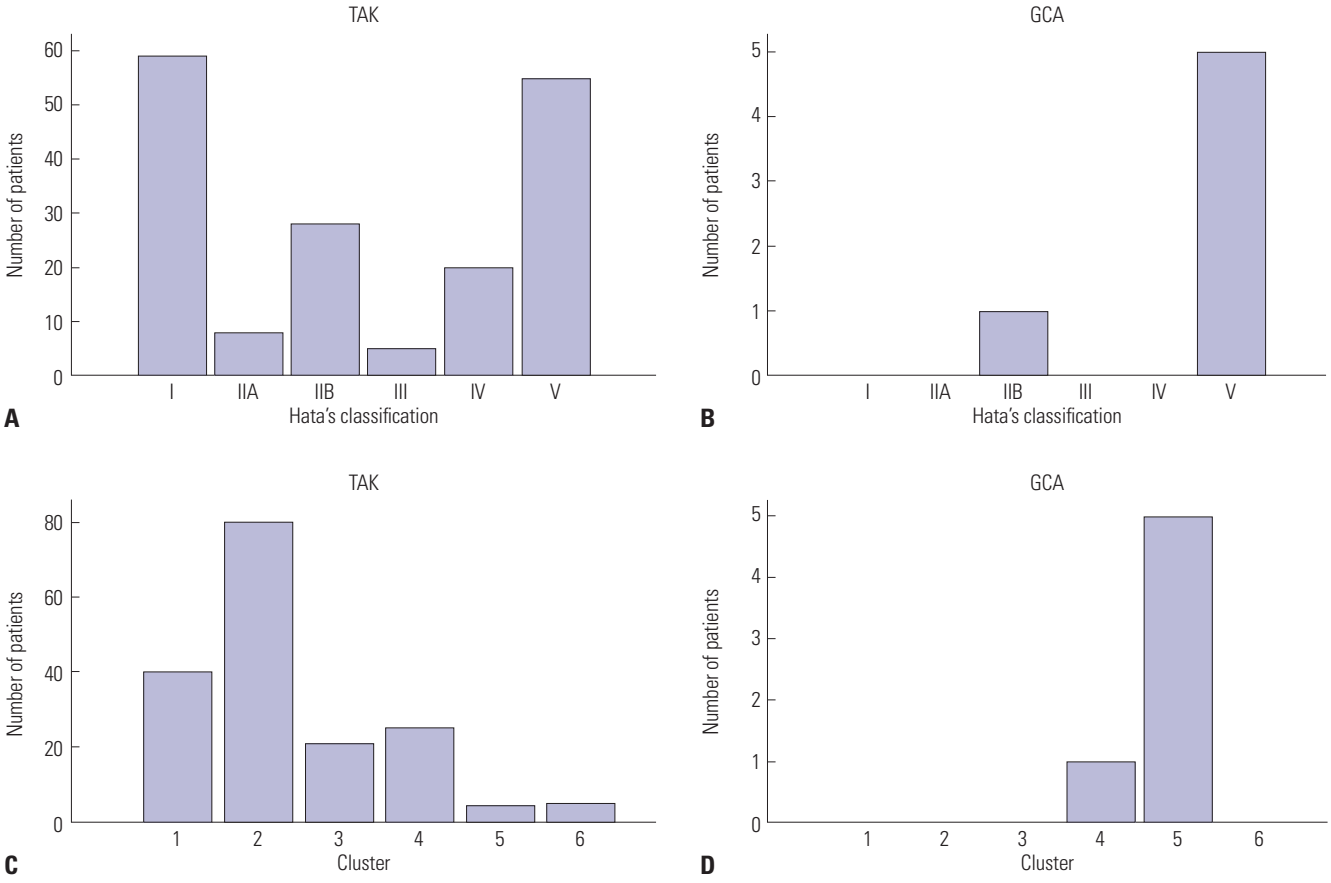

Fig. 1. Distribution of (A) patients with TAK according to Hata's classification, (B) patients with GCA according to Hata's classification, (C) patients with TAK according to clusters, and (D) patients with GCA according to clusters. GCA, giant cell arteritis; TAK, Takayasu arteritis.

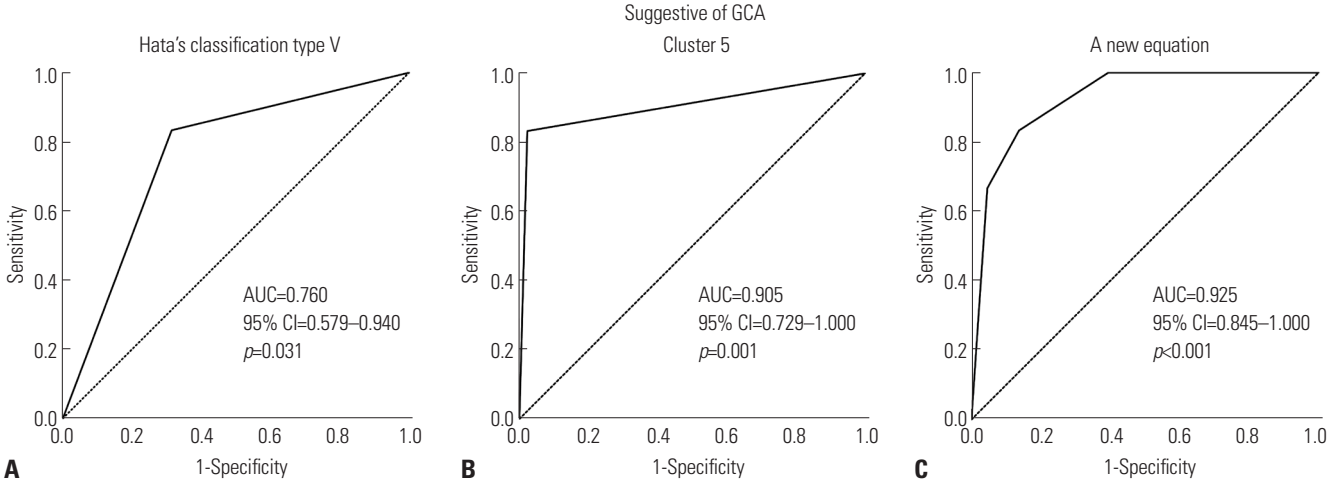

Fig. 2. ROC curve analysis of (A) Hata's classification type V, (B) cluster 5, and (C) the combination of right subclavian artery and aortic arch. AUC, area under the curve; CI, confidence interval; GCA, giant cell arteritis; ROC, receiver operating characteristic.

DISCUSSION

In this study, we tested the accuracy of Hata's classification and clusters in distinguishing TAK and GCA. Hata's classification type V (AUC=0.760, 95% CI=0.579–0.940, p=0.031) and cluster 5 (AUC=0.905, 95% CI=0.729–1.000, p=0.001) were both statistically significant in distinguishing TAK and GCA, with cluster 5 being more accurate. Moreover, we found that incorporating the involvement of right subclavian artery and aortic arch yielded the highest accuracy (AUC=0.925, 95% CI=0.845–1.000, p< 0.001) in differentiating TAK and GCA.

TAK and GCA share overlapping features, as both are charac-

Table 3. Multivariable Logistic Regression Analysis with Backward Elimination Method

	Final step		
	β coefficient	OR (95% CI)	*p*
Model 1*: Hata's classification			
Type V	2.390	10.909 (1.245–95.604)	0.031
Model 2†: Cluster			
Cluster 5	5.365	213.750 (20.084–2274.853)	<0.001
Model 3‡: LV involvement			
Right subclavian artery	2.358	10.571 (1.106–101.062)	0.041
Aortic arch	3.385	29.516 (3.152–276.385)	0.003

CI, confidence interval; LV, large-vessel; OR, odds ratio.
*Model 1 was conducted to identify possible combination of covariates among Hata's classification types. Only type V was included in the initial step and therefore remained in the final step; †Model 2 was conducted to identify possible combination of covariates among clusters. Clusters 2 and 5 were included in the initial step. Cluster 2 was eliminated in the initial step, leaving only cluster 5 in the final step; ‡Model 3 was conducted to identify possible combination of covariates among the 14 territories. Right subclavian artery, aortic arch, descending aorta, and abdominal aorta were included in the initial step. The descending aorta was eliminated in the initial step, and the abdominal aorta was eliminated in the second step. Right subclavian artery and aortic arch remained in the final step. Based on Model 3, the following equation was derived: 2.358×right subclavian artery involvement (yes=1; no=0)+3.385×aortic arch involvement (yes=1; no=0).

terized by granulomatous inflammation of the LV. This has led to speculation that both diseases could belong to a single disease spectrum.[10,17] However, the two diseases also have substantial differences in epidemiology, genetics, and treatment response.[18] TAK is more common in Asians, whereas GCA is more common in Caucasians. Age at onset is younger in TAK than in GCA.[18] Regarding treatment response, tocilizumab is more effective in GCA than in TAK.[19-21] Despite some shared features between TAK and GCA, these differences indicate that considering them as distinct diseases remains clinically relevant. Our data have clinical implications, as they provide a practical tool for distinguishing these two forms of LVV. In particular, given that LV involvement is observed in approximately 67% of patients with GCA,[22] the differential diagnosis between TAK and GCA is increasingly encountered in clinical practice. The findings of this study may assist clinicians in navigating this diagnostic challenge with improved accuracy.

Although clinical parameters such as age, cranial symptoms, and presence of PMR could aid in distinguishing LV-GCA from TAK, their utility is often limited. Compared to cranial GCA, patients with LV-GCA tend to have a younger age of onset (≤64 years) and less frequent cranial symptoms,[23] making clinical differentiation from TAK particularly challenging. In addition, although the presence of PMR can be a useful distinguishing feature, PMR is observed in only 22%–28% of patients with LV-GCA,[24,25] limiting its utility in the majority of cases. In contrast, imaging studies are routinely performed as part of the diagnostic work-up in all patients, making them a more universally applicable and advantageous tool for differentiating LV-GCA from TAK.

The proportions of patients according to Hata's classification and clusters in our study were similar to that in previous studies.[3,14] As reported in a previous study from Japan on TAK,[3] in patients with TAK in our cohort, Hata's classification type I (33.7%) was the most common type, followed by type V (31.4%). In addition, similar to the previous study from the United States,[14] cluster 2 was more common in TAK than in GCA, and cluster 5 was more common in GCA than in TAK. These similarities with the previous studies reflect the external validity of our study cohort.

Furthermore, we newly reported the distribution of patients with GCA according to Hata's classification. The majority of the patients with GCA were type V (83.3%), which was significantly higher (p=0.016) than the proportion of patients with TAK classified as type V (31.4%). This significant difference between TAK and GCA indicates that Hata's classification type V can be used as a tool for distinguishing TAK and GCA. Indeed, we found that type V was statistically significant (p=0.031) in distinguishing TAK and GCA, with an AUC of 0.760. In addition, cluster 5 according to the cluster-based classification was also statistically significant (p=0.001) in distinguishing TAK and GCA (AUC 0.905). Notably, type V and cluster 5 are the most extensive patterns of LV involvement in Hata's classification and cluster-based classification, respectively. This suggests that the extent of LV involvement could be the key to differentiate TAK (less extensive) and GCA (more extensive). Moreover, compared with type V, cluster 5 is more extensive in terms of LV involvement. In cluster 5, the entire aorta and the aortic branches are involved, while in type V, the abdominal aorta may not be involved (cases of type IIB+renal artery involvement without abdominal aorta involvement are classified as type V). Therefore, the higher AUC of cluster 5 than type V also indicates that more extensive disease favors the diagnosis towards GCA than TAK.

In addition to Hata's classification- and cluster-based differentiation of TAK and GCA, we newly identified an LV involvement pattern that could more accurately differentiate TAK and GCA. The combination of right subclavian artery and aortic arch involvement [2.358×right subclavian artery involvement (yes=1; no=0)+3.385×aortic arch involvement (yes=1; no=0)] was highly accurate in distinguishing TAK and GCA (AUC=0.925). The optimal cut-off value of the equation was 2.872, indicating that aortic arch involvement alone (score=3.385), or in combination with right subclavian artery involvement (score=5.743), would exceed the threshold. This suggests that aortic arch involvement alone or in combination with right subclavian artery involvement would favor the diagnosis of GCA. This finding is intriguing in that this tool does not necessarily indicate that more extensive disease is more likely GCA, in contrast to Hata's classification- and cluster-based differentiation. In other words, this tool could be useful in differentiating TAK and

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GCA regardless of the extent of the disease. However, it is unclear why only the right subclavian artery, and not the left subclavian artery, is useful in differentiating TAK and GCA. The right subclavian artery branches from the brachiocephalic trunk, whereas the left subclavian artery branches directly from the aortic arch. We speculate that it may be more appropriate to combine territories that are not continuous (i.e., independent) to produce a more accurate differentiation tool. Therefore, it seems plausible to combine aortic arch with the right subclavian artery, which does not directly branch from the aortic arch, rather than the left subclavian artery. Indeed, skip lesions have been reported in temporal artery biopsies of patients with GCA,[26,27] suggesting that non-contiguous vessel involvement may be a characteristic feature of this disease. This feature may also extend to extracranial LVs and could potentially serve as a distinguishing factor from TAK. However, given the observational nature of our study, the exact reason why the combination of right subclavian artery and aortic arch is accurate in differentiating TAK and GCA remains uncertain, and further investigation is warranted. Nonetheless, our findings offer a practical approach for improving the differential diagnosis of TAK and GCA in clinical practice.

There are some limitations to be noted in our study. First, the number of patients with GCA was small, and further validation studies with larger cohorts are warranted. Second, mechanistic understanding of why the LV involvement pattern differs between TAK and GCA cannot be drawn from our data. Integration of molecular and genetic analyses with imaging data in future studies could provide deeper insights into these diseases.

In conclusion, TAK and GCA showed different patterns of LV involvement, which could be used in differentiating the two diseases. Hata's classification- and cluster-based differentiation were both accurate in distinguishing TAK and GCA, with the cluster-based differentiation having a higher accuracy. Moreover, we found that aortic arch involvement, either alone or in combination with right subclavian artery involvement, could more accurately distinguish TAK and GCA. By highlighting their distinct yet overlapping features, our findings pave the way for improved differential diagnosis between TAK and GCA.

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AUTHOR CONTRIBUTIONS

Conceptualization: Sang-Won Lee. Data curation: Oh Chan Kwon, Jang Woo Ha, and Sang-Won Lee. Formal analysis: Oh Chan Kwon, Jang Woo Ha, and Sang-Won Lee. Funding acquisition: Sang-Won Lee. Investigation: all authors. Methodology: all authors. Project administration: Oh Chan Kwon, Jang Woo Ha, and Sang-Won Lee. Resources: all authors. Software: Oh Chan Kwon, Jang Woo Ha, and Sang-Won Lee. Supervision: Sang-Won Lee. Validation: all authors. Visualization: Oh Chan Kwon, Jang Woo Ha, and Sang-Won Lee. Writing—original draft: Oh Chan Kwon. Writing—review & editing: Oh Chan Kwon, Jang Woo Ha, and Sang-Won Lee. Approval of final manuscript: all authors.

ORCID iDs

Oh Chan Kwon https://orcid.org/0000-0001-7962-3697
Jang Woo Ha https://orcid.org/0000-0002-3307-5215
Min-Chan Park https://orcid.org/0000-0003-1189-7637
Yong-Beom Park https://orcid.org/0000-0003-4695-8620
Sang-Won Lee https://orcid.org/0000-0002-8038-3341

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