· Article ·

Value of conventional ultrasound and contrast-enhanced ultrasound in the diagnosis and follow-up of transient perivascular inflammation of the carotid artery syndrome

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Abstract

Background Transient perivascular inflammation of the carotid artery (TIPIC) syndrome is relatively rare. Current research on conventional ultrasound and contrast-enhanced ultrasound (CEUS) for examining this condition is predominantly confined to case reports. Therefore, this study aimed to evaluate the value of conventional ultrasound and CEUS in the diagnosis and follow-up of TIPIC syndrome.

Methods The study conducted a retrospective analysis of 30 patients with TIPIC syndrome who were treated between January 2016 and September 2025. We analyzed their conventional ultrasonographic and CEUS features and compared the evolution of these characteristics during follow-up visits (14 days, 1 month, 3 months, and 6 months).

Results The mean (± standard deviation) maximum thickness of the lesions was 4.4 ± 0.9 mm, and the mean involved length of the lesions was 24.2 ± 8.1 mm. A Pearson correlation analysis showed that the maximum thickness of the lesions was positively correlated with lesion length at the initial visit, 14-day follow-up, and 1-month follow-up (r = 0.442, r = 0.465, and r = 0.802; $P = 0.014$, $P < 0.001$, and $P < 0.001$, respectively). On conventional ultrasound, TIPIC lesions typically presented as unilateral (100%), eccentric (100%), with perivascular wall thickening of the common carotid artery or its bifurcation (100%), and appeared as hypoechoic areas without luminal stenosis (100%). On CEUS, these lesions were mainly diffuse (93.3%) and showed hyperenhancement (90%). During the follow-up, all patients showed a gradual reduction in the lesion thickness and involved area (both $P < 0.001$), accompanied by significantly decreased CEUS enhancement intensity ($P < 0.001$). Most lesions resolved completely within 3 months or earlier (93.3%).

Conclusions Conventional ultrasound and CEUS can provide diagnostic imaging evidence for TIPIC syndrome. These techniques play a crucial role in the diagnosis, evaluation of treatment efficacy, and follow-up monitoring of this syndrome, and should be considered the first-line imaging modality.

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Keywords: transient perivascular inflammation of the carotid artery (TIPIC) syndrome, ultrasound, contrast-enhanced ultrasound (CEUS)

Introduction

Transient perivascular inflammation of the carotid artery (TIPIC) syndrome was formerly known as idiopathic carotidynia or Fay syndrome, which was first described by Fay in 1927 [1]. The current terminology of TIPIC syndrome was proposed by Lecler et al. in 2017 [2, 3]. This syndrome is a relatively rare vascular disease that accounts for 2.8% of cases in patients presenting with acute neck pain, and it is more common in individuals aged 39 to 56 years [2, 4]. TIPIC syndrome is characterized by a transient inflammation of the tissues surrounding the carotid artery, typically manifesting as acute unilateral carotid artery tenderness and self-limiting neck pain, which can radiate to adjacent areas[4]. This pain may sometimes intensify because of activities, such as movement, swallowing, chewing, coughing, or yawning [5]. Previous studies have proposed that the diagnostic criteria for TIPIC syndrome include primary and secondary criteria. The primary criteria include the following: acute pain in the carotid artery, accompanied or not accompanied by radiating pain in the head; infiltration around the peripheral blood vessels as shown by imaging; other vascular or nonvascular diseases excluded through imaging techniques; and improvement of symptoms spontaneously or through anti-inflammatory treatment within 14 days. The secondary criterion is that the lesion can disappear on its own [2, 3, 6].

Currently, the etiology, predisposing factors, and pathophysiological mechanisms of TIPIC syndrome remain unclear and lack definitive research conclusions. Previous studies have suggested that the occurrence of TIPIC syndrome is associated with factors such as unexplained inflammation, viral infections, certain medication effects, variations in large vessel vasculitis, or autoimmune responses [7-10]. Furthermore, the clinical manifestations of TIPIC (e.g., neck pain and tenderness) lack specificity and can easily be confused with other carotid artery diseases (e.g., atherosclerotic plaques, large vessel vasculitis, and carotid artery dissection) or neck masses, making imaging examinations crucial.

The advantages of ultrasound examinations, such as non-invasiveness, high reproducibility, low cost, a flexible operation, and the ability for dynamic scanning, mean that they are currently widely applied in the examination and diagnosis of carotid artery diseases[11]. Moreover, because of the high temporal and spatial resolution of ultrasound, it can visualize the subtle changes in each layer of blood vessels. Therefore, an ultrasound examination can effectively evaluate blood flow in the carotid artery, the condition of the vessel wall, and the surrounding tissues of the blood vessels [12], which provides a unique advantage and value in the diagnosis and follow-up of TIPIC syndrome. Rafailidis et al.[12] pointed out that ultrasound is the preferred examination method for evaluating TIPIC syndrome. A retrospective cohort study by Micieli et al. on 72 patients with TIPIC syndrome also confirmed the importance of ultrasound in the follow-up of this disease [4].

With the development of technology, contrast-enhanced ultrasound (CEUS) has gradually been applied in the diagnosis of TIPIC syndrome because of its advantages. These advantages include its relatively simple operation and the ability to quickly and accurately

locate the pain site, perform multi-angle scans, and dynamically observe the grayscale distribution, blood flow, blood supply, and perfusion enhancement of the patient's lesion site in real time; thus, it has high diagnostic value [12, 13]. However, most of the previous studies on the diagnosis or follow-up of TIPIC syndrome using ultrasound and CEUS are case reports [1, 3, 13-15]. Therefore, more evidence from TIPIC syndrome cases is required.

In this study, we retrospectively analyzed conventional ultrasonographic and CEUS features of TIPIC syndrome lesions in our center over the past 10 years. We aimed to examine the value of these techniques in the diagnosis and follow-up of TIPIC syndrome, and to provide more information on clinical diagnosis, treatment, and follow-up monitoring of lesions.

Methods

Ethics statement

This study was approved by the Ethics Committee of Chinese PLA General Hospital on December 26, 2024 (S2024-804-01). All participants signed a written informed consent form.

Patients

Patients who were diagnosed with TIPIC syndrome and underwent conventional ultrasound and CEUS examinations at the First Medical Center of the Chinese People's Liberation Army General Hospital between January 2016 and September 2025 were included in the study. All patients were required to meet the following diagnostic criteria [2, 3, 6]: (1) acute pain in the carotid artery, accompanied or not accompanied by radiating pain in the head; (2) imaging showed infiltration around the peripheral blood vessels; (3) exclusion of other vascular or nonvascular diseases using imaging techniques (computed tomography, magnetic resonance, ultrasound, or CEUS); and (4) improvement of symptoms spontaneously or by anti-inflammatory treatment within 14 days.

Patients younger than 18 years and those with contraindications for a CEUS examination (e.g., pregnancy, unstable angina, allergic reactions, and lesions with right-to-left shunt in the heart) were excluded. Finally, 30 patients (17 women and 13 men) were enrolled.

Conventional ultrasound and CEUS examinations

Conventional ultrasound examinations were performed using the Philips EPIQ 7 ultrasound system (Philips Healthcare, Bothell, WA, USA) equipped with an L12-5 linear array transducer. This examination focused on the patient's reported pain area and captured transverse and longitudinal full-length views of the perivascular lesion adjacent to the affected carotid artery. The recorded data included the lesion's location, morphology, maximum thickness, length, internal echogenicity, and relationship to the carotid arterial wall, status of the carotid lumen, and cervical lymph node characteristics.

CEUS examinations were performed using the Mindray Resona R9 ultrasound system (Shenzhen Mindray Bio-Medical Electronics Co., Ltd., Shen Zhen, Guang Dong, China) equipped with an L11-3U linear array transducer. Following a conventional ultrasound examination, the system was switched to CEUS mode (mechanical index set at 0.06). The transducer was focused on the largest cross-section of the lesion, and this ensured that the target area remained centered in the image. A 1.2-mL bolus of SonoVue contrast agent (Bracco S.p.A., Italy) was injected intravenously via the median cubital vein, followed by a 5.0-mL saline flush. CEUS images and cine loops were continuously

recorded from 10 to 120 seconds post-injection for subsequent analysis. The CEUS characteristics of the lesions were documented, including enhancement patterns and enhancement intensity. If necessary, repeated injections and examinations were performed to evaluate other lesion sites. After the CEUS examination, the patients were advised to remain under observation for 30 minutes to monitor for potential complications.

The conventional ultrasound images and CEUS dynamic videos of all patients were analyzed by two ultrasound doctors with more than 5 years of experience in ultrasound and CEUS operations. If there was a disagreement of opinion between the doctors, a senior doctor was requested to participate in the discussion.

Data collection and follow-up

In addition to conventional ultrasonographic and CEUS imaging characteristics, we collected and recorded the following data for each patient: demographic characteristics, such as age and sex; recent or past medical history; presence or absence of major cardiovascular and cerebrovascular risk factors (hypertension, smoking, diabetes, hyperlipidemia, and atherosclerotic vascular diseases); laboratory test results; clinical manifestation data (e.g., pain intensity, pain location, pain relief time, presence or absence of local swelling or tenderness or enlarged lymph nodes during palpation, and presence or absence of fever and headache); and medication use and treatment regimens.

The patients were typically scheduled for follow-up visits at 14 days, 1 month, 3 months, and 6 months after the initial consultation. During each follow-up, the above-mentioned clinical, laboratory, and imaging data were documented. If conventional ultrasound indicated complete resolution of the lesion, a subsequent CEUS examination was performed according to the patient's preference.

Statistical analysis

Statistical analysis was performed using IBM SPSS 26.0 (IBM Corp., Armonk, NY, USA). Quantitative data are expressed as the mean ± standard deviation or as the median and quartiles 1–3 (Q1–Q3), and qualitative data are presented as the frequency. To analyze continuous variables that conformed to a normal distribution, the t-test was used to evaluate the differences between groups. Regarding non-continuous variables or continuous variables that did not meet a normal distribution, the Mann–Whitney U test was used to analyze the differences between groups. A Pearson correlation analysis was used to analyze the relationship between two continuous variables that followed a normal distribution. $P < 0.05$ was considered statistically significant.

Results

Characteristics of the study population

The baseline characteristics and clinical manifestations of patients with TIPIC syndrome are shown in Table 1. The mean age of the patients in this study was 40.9 ± 11.2 years. The proportion of patients with cardiovascular and cerebrovascular risk factors among the 30 patients was relatively low. The highest proportions of risk factors were for hypertension (10%) and hyperlipidemia (10%). Only one (3.3%) patient had a recent viral infection. No patients had any recent history of neck massage or neck trauma. Laboratory examinations showed that 14 (43.3%) of 30 patients had an elevated erythrocyte sedimentation rate, with a mean rate of 21.5 ± 24.7 mm/h. Ten (33.3%) patients had elevated C-reactive protein concentrations, with a mean concentration of 11.4 ± 21.1 mg/L. Regarding

Table 1. Baseline characteristics and clinical manifestations of patients with TIPIC syndrome.

Variables	Total(N=30)
Gender	
Male (%)	13 (43.3)
Female (%)	17 (56.7)
Age (years)($\bar{x}\pm s$)	40.9 ± 11.2
Major cardiovascular and cerebrovascular risk factors	
Hypertension (%)	3 (10.0)
Smoking (%)	2 (6.7)
Diabetes (%)	1 (3.3)
Hyperlipidemia (%)	3 (10.0)
Atherosclerotic vascular diseases (%)	1 (3.3)
Recent viral infections (%)	1 (3.3)
Recent neck massage (%)	0
Recent neck injury (%)	0
Laboratory test	
Erythrocyte sedimentation rate (mm/H) ($\bar{x}\pm s$)	21.5 ± 24.7
C-reactive protein (mg/L) ($\bar{x}\pm s$)	11.4 ± 21.1
Pain intensity	
Mild (%)	12 (40.0)
Moderate (%)	17 (56.7)
Severe (%)	1 (3.3)
Side of symptoms	
Right (%)	14 (46.7)
Left (%)	16 (53.3)
Both side (%)	0
Local swelling (%)	2 (6.7)
Enlarged lymph nodes at palpation (%)	4 (13.3)
Fever (%)	5 (16.7)
Headache (%)	2 (6.7)
Medication use	22 (73.3)
Treatment regimens	
Non-steroidal anti-inflammatory drugs (%)	16 (72.7)
Glucocorticoids (%)	6 (27.3)
Pain relief time (days)(Q_1-Q_3)	13 (12-14)

Notes: TIPIC, transient perivascular inflammation of the carotid artery

clinical manifestations, all patients presented with neck pain. Most patients described the pain as mild (40%) or moderate (56.7%). All symptoms occurred unilaterally (100%). Only four (13.3%) patients had palpable enlarged lymph nodes and two (6.7%) felt local swelling. Other symptoms included fever (16.7%) and headache (6.7%). Most (73.3%) patients received drug treatment, including non-steroidal anti-inflammatory drugs (72.7%) and glucocorticoids (27.3%).

Imaging characteristics

Table 2 shows the conventional ultrasonographic and CEUS characteristics of the 30 lesions included in the study. Ultrasound showed that all 30 lesions presented as localized, thickened, hypoechoic areas around the carotid artery wall, with ill-defined boundaries from the normal carotid artery wall. The mean maximum thickness of the lesions was 4.4 ± 0.9 mm, and the mean involved length of the lesions was 24.2 ± 8.1 mm. The Pearson correlation analysis showed a positive linear correlation between these two variables (r = 0.442, P = 0.014) (Figure 1). All lesions showed an eccentric distribution (100%). Most lesions involved the common carotid artery (46.7%) or carotid bifurcation (53.3%), and approximately two-thirds of the lesions were located in the posterior (36.7%) or lateral (30.0%) aspects of the carotid artery. None of the lesions caused carotid artery stenosis. Color Doppler ultrasound showed no hemodynamically significant changes in carotid blood

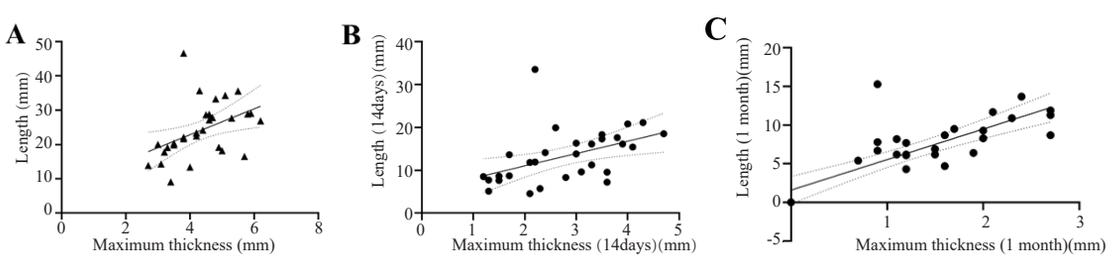


Figure 1. The maximum thickness of the lesions was positively correlated with the length of the lesions at the initial visit (A), 14-day follow-up (B), and 1-month follow-up (C) (r = 0.442, r = 0.465, and r = 0.802; P = 0.014, P < 0.001, and P < 0.001, respectively)

flow due to any lesion. Cervical lymphadenopathy was detected by conventional ultrasound in 20% (6/30) of the patients. All lesions underwent a CEUS examination, among which 28 (93.3%) lesions showed a diffuse enhancement pattern, one (3.3%) showed linear enhancement, and one (3.3%) showed diffuse enhancement in the proximal portion with no enhancement in the distal portion. Regarding the enhancement intensity, the majority (90%) of the lesions showed hyperenhancement.

Table 2. Conventional ultrasonographic and CEUS imaging characteristics of patients with TIPIC syndrome.

Variables	Total(N=30)
Location	
Common carotid artery (%)	14 (46.7)
Bifurcation of the common carotid artery (%)	16 (53.3)
Internal carotid artery (%)	0 (0.0)
External carotid artery (%)	0 (0.0)
Distribution	
Concentric (%)	0 (0.0)
Eccentric (%)	30 (100.0)
Relative position to the carotid artery	
Anterior (%)	6 (20.0)
Posterior (%)	11 (36.7)
Lateral (%)	9 (30.0)
Medial (%)	4 (13.3)
Internal echo	
Hypoecho (%)	30 (100.0)
Relation to the carotid artery wall	
Unclear demarcation (%)	30 (100.0)
Maximum thickness (mm) ($\bar{x}\pm s$)	4.4 ± 0.9
Length (mm) ($\bar{x}\pm s$)	24.2 ± 8.1
Lumen stenosis	0 (0.0)
Enlarged cervical lymph nodes (%)	6 (20.0)
CEUS enhancement intensity	
High enhancement (%)	27 (90.0)
Slightly high enhancement (%)	2 (6.7)
Equal enhancement (%)	1 (3.3)
Low enhancement (%)	0 (0.0)
CEUS enhancement mode	
Diffuse enhancement (%)	28 (93.3)
Linear enhancement (%)	1 (3.3)
Diffuse enhancement at the proximal end and no enhancement at the distal end (%)	1 (3.3)

Notes: CEUS, contrast-enhanced ultrasound; TIPIC, transient perivascular inflammation of the carotid artery.

Follow-up results

During the follow-up period, neck symptoms resolved in all patients after a median of 13 days (Q1–Q3: 12–14 days), with no recurrence observed in any patient during the 6-month follow-up. The lesions completely resolved in 6 (20.0%) patients by the 1-month follow-up and in 28 (93.3%) patients by the 3-month follow-up, with complete resolution achieved in all patients by the 6-month follow-up. With a prolonged follow-up duration, conventional ultrasound showed a significant progressive reduction in the maximum thickness and length of the lesions compared to the initial visit (all $P < 0.001$), and at each of the 14-day, 1-month, and 3-month follow-ups, the maximum thickness and length of the lesions were significantly reduced compared to the previous follow-up (Table 3, Figures 2, 3) (all $P < 0.001$). A positive correlation was also observed between the maximum thickness and involved length of the lesions at the 14-day and 1-month follow-ups ($r = 0.465$, $r = 0.802$, respectively; both $P < 0.001$). CEUS showed no significant changes in the enhancement patterns of the lesions over the follow-up period (all $P > 0.05$), while the enhancement intensity progressively decreased compared to the initial visit (Table 4, Figures 2, 3) (all $P < 0.001$).

Discussion

The diagnosis and identification of TIPIC syndrome are crucial for its subsequent treatment and management. This retrospective analysis of conventional ultrasound and CEUS imaging data from 30 patients with TIPIC syndrome over the past decade showed an important role of these techniques in detecting and diagnosing this condition. We found that TIPIC lesions on conventional ultrasound typically presented as eccentric perivascular wall thickening at the unilateral

common carotid artery or its bifurcation and appeared as hypoechoic areas without causing luminal stenosis. CEUS showed that these lesions predominantly exhibited diffuse hyperenhancement, which is consistent with previous studies [4, 12]. These characteristics provide important imaging evidence for the accurate diagnosis of TIPIC syndrome.

Previous histological evaluations have shown that the pathological features of TIPIC syndrome include vascular proliferation, fibroblast proliferation, and low-grade chronic active inflammation. This inflammation predominantly involves lymphocytes, along with a small number of polymorphonuclear leukocytes and mast cells. There is a major presence of eosinophils in TIPIC syndrome, but early fibrosis occurs. The most prominent histological change in this syndrome is a fibromyxoid stroma with edema, which contains abundant fibroblasts and proliferating small vessels with prominent endothelial cells [14, 16]. These inflammatory

Table 3. Changes in lesion characteristics on conventional ultrasound at each follow-up time point.

Follow-up time (n)	Maximum thickness(mm)	*P* value*	Length(mm)	*P* value#
Initial visit（30）	4.4 ± 0.9 [bcde]	-	24.2 ± 8.1 [bcde]	-
14 days（30）	2.8 ± 1.0 [acde]	＜0.001	14.0 ± 6.0 [acde]	＜0.001
1 months（24）	1.6 ± 0.6 [abde]	＜0.001	8.4 ± 2.8 [abde]	＜0.001
3 months（2）	1.0 ± 0.1 [abc]	＜0.001	6.7 ± 0.8 [abc]	＜0.001
6 months（0）	0 [abc]	＜0.001	0 [abc]	＜0.001

*Compared with maximum lesion thickness at the initial visit; #Compared with lesion length at the initial visit.
[a]Compared with the initial visit, $P < 0.001$. [b]Compared with the 14-day follow-up, $P < 0.001$. [c]Compared with the 1-month follow-up, $P < 0.001$. [d]Compared with the 3-month follow-up, $P < 0.001$. [e]Compared with the 6-month follow-up, $P < 0.001$.

Table 4. Changes in lesion characteristics on CEUS at each follow-up time point.

Follow-up time (n)	CEUS enhancement mode (n)			*P* value*	CEUS enhancement intensity (n)				*P* value#
	Diffuse enhancement	Linear enhancement	Diffuse enhancement at the proximal end and no enhancement at the distal end		High enhancement	Slightly high enhancement	Equal enhancement	Low enhancement	
Initial visit（30）	28 (93.3)	1 (3.3)	1 (3.3)	-	27 (90)	2 (6.7)	1 (3.3)	0 (0.0)	-
14 days（30）	29 (96.7)	0	1 (3.3)	1.000	5 (16.7)	19 (63.3)	5 (16.7)	1 (3.3)	＜0.001
1 months（24）	24 (100.0)	0	0	0.500	0 (0.0)	4 (16.7)	12 (50.0)	8 (33.3)	＜0.001
3 months（2）	2 (100.0)	0	0	1.000	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)	0.500
6 months（0）	0	0	0	-	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	-

*Compared with the CEUS enhancement mode at the initial visit; #compared with the CEUS enhancement intensity at the initial visit.

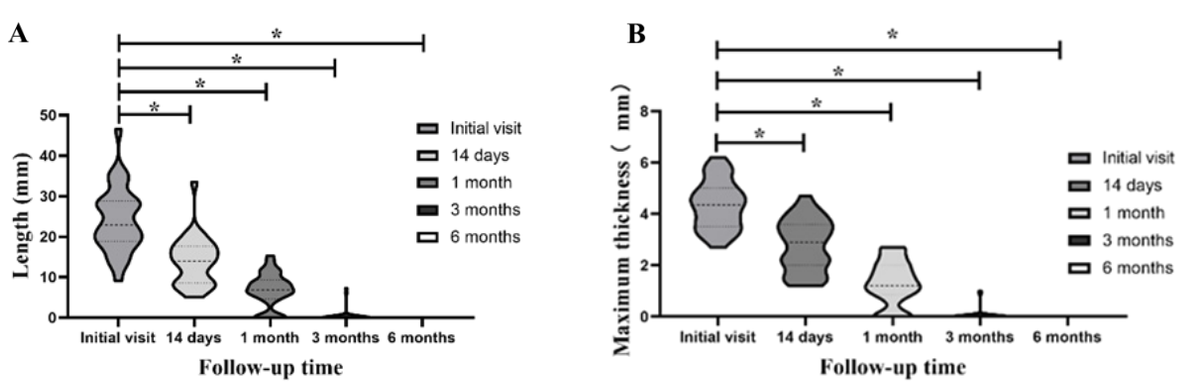


Figure 2. Comparison of the maximum thickness (A) and the length (B) of lesions at each follow-up time point (*indicates a statistically significant difference, $P < 0.001$).

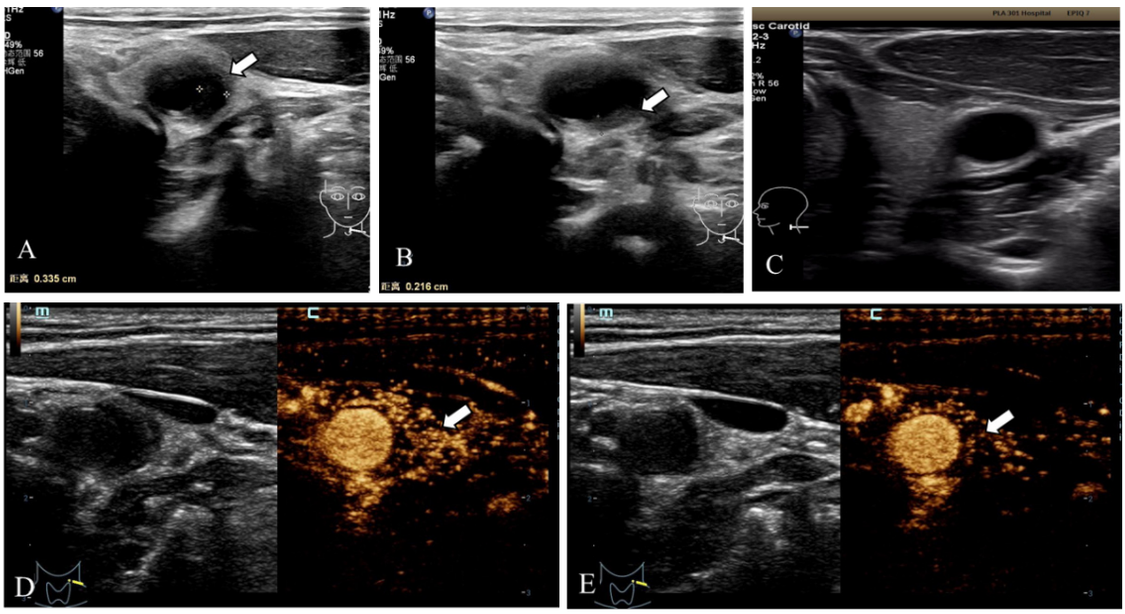


Figure 3. Ultrasonographic features on conventional grayscale ultrasound and CEUS in a 38-year-old male patient at the initial visit and during follow-up after treatment (arrows).

Conventional ultrasound images obtained at the initial visit (A), 14-day follow-up (B), and 1-month follow-up (C) showing complete resolution of the lesion by the 1-month follow-up. CEUS images acquired at the initial visit (D) and 14-day follow-up (E).

alterations are likely responsible for modifying the acoustic interface of tissue, thereby manifesting as focally thickened hypoechoic areas on ultrasound. This study showed that TIPIC syndrome typically presented with diffuse hyperenhancement on CEUS, which suggested abundant dilated capillaries and pathological neovascularization in the affected area. This finding aligns with previously documented pathological changes of vascular proliferation in TIPIC syndrome [16]. Moreover, the presence of active inflammation may lead to increased local microvascular permeability and enhanced blood flow[17], further suggesting that TIPIC syndrome represents an active inflammatory process rather than a fibrotic or degenerative condition.

Our study showed a positive correlation between lesion length and thickness that persisted throughout the follow-up period, which is consistent with previous studies [4]. This finding indicates that the disease burden may also be expressed quantitatively. Future studies need to further investigate the relationship between lesion size and symptom types based on these findings.

The diagnosis of TIPIC syndrome requires the exclusion of other vascular or nonvascular disorders that may cause neck pain or cervical discomfort, such as carotid atherosclerotic plaques, carotid artery dissection, large vessel vasculitis, and invasive neck tumors. Patients with atherosclerotic plaques are typically older in age and often present with comorbidities, such as hypertension, hyperlipidemia, and hyperglycemia. These plaques are located within the intima and frequently manifest as irregular, heterogeneous echogenic structures, often accompanied by calcification (hyperechoic with acoustic shadowing), and typically cause luminal stenosis [18-20]. While the CEUS characteristics of plaques vary, typical active plaques may have neovascularization but generally show punctate or linear focal enhancement rather than the diffuse homogeneous hyperenhancement

characteristic of TIPIC [21]. Carotid artery dissection may also present with unilateral neck pain. However, ultrasound imaging of carotid artery dissection typically shows widening of the affected lumen with fluttering of the dissected intimal flap, forming true and false lumens. The lumen may become stenotic or occluded, and color Doppler often shows abnormal blood flow patterns, frequently accompanied by hemodynamic changes [22]. These features are distinctly different from the sonographic characteristics of TIPIC syndrome. Takayasu arteritis commonly occurs in younger patients. Ultrasound imaging of Takayasu arteritis typically shows disappearance of the normal vessel wall structure. This condition presents with diffuse, homogeneous, concentric wall thickening over a long segment, accompanied by varying degrees of luminal stenosis or even occlusion, which may be associated with thrombosis [23, 24]. In contrast, the eccentric and focal distribution of TIPIC syndrome serves as a key distinguishing feature. Regarding neck tumors, when they invade the vascular wall, the CEUS pattern tends to be more heterogeneous. Additionally, these lesions demonstrate progressive growth and do not rapidly resolve with anti-inflammatory therapy, unlike TIPIC syndrome. Therefore, when features, such as eccentric wall thickening with hypoechogenicity and diffuse hyperenhancement on CEUS appear concurrently, a diagnosis of TIPIC syndrome should be strongly suspected. The combined analysis of multiple imaging indicators considerably enhances the ability to differentiate TIPIC syndrome from other cervical pathologies.

Because of the self-limiting nature of TIPIC syndrome or its favorable response to pharmacotherapy [25], imaging follow-up to confirm the resolution of lesions is crucial for verifying its diagnosis and guiding treatment. This study showed that during follow-up, a gradual reduction in lesion thickness and involved length, along with significantly decreased CEUS enhancement intensity were observed in all patients. Most lesions resolved completely within 3 months or earlier, while some showed slower regression, and required up to 6 months for complete resolution. This delayed resolution may be attributed to persistent low-grade chronic inflammation concurrent with localized fibrotic deposition [4]. Furthermore, this dynamic progression during follow-up not only validates the initial diagnosis but also provides clinicians with objective imaging evidence for discontinuing treatment. Compared with computed tomography or magnetic resonance imaging, ultrasound and CEUS offer unparalleled advantages, including a radiation-free operation, procedural convenience, and multi-planar scanning capabilities, making them ideal tools for monitoring the progression of TIPIC syndrome.

In contrast to a study by Micieli et al.[4] who found a recurrence rate of 20% in TIPIC syndrome, our study showed that none of the 30 patients experienced recurrence during the follow-up period. This discrepancy between studies may be attributed to the limited sample size in our study and the fact that some patients' mild and rapidly improving symptoms might have been overlooked, potentially leading to an underestimation of the actual recurrence rate.

This study has several limitations. First, this was a single-center, retrospective investigation with a limited sample size. Second, the final diagnosis was not based on the gold standard of pathology, but relied on conventional ultrasound and CEUS findings combined with clinical follow-up results. While this approach aligns with standard clinical practice for this condition, it may introduce potential bias. Finally, although the relationship between TIPIC syndrome and cardiovascular and cerebrovascular events remains unclear, previous studies have suggested that

ischemic stroke promotes endothelial infection and inflammation, which under conditions of oxidative stress, could trigger TIPIC syndrome. However, because of the insufficient sample size, this study did not investigate the association between TIPIC syndrome and major risk factors for cardiovascular and cerebrovascular diseases. Therefore, future multicenter, prospective studies with larger sample sizes are required to further validate these findings and provide a more robust theoretical foundation for clinical practice.

Nevertheless, this study indicates that conventional ultrasound and CEUS can provide diagnostic imaging evidence for TIPIC syndrome. These techniques play a central role in the diagnosis, differential diagnosis, evaluation of treatment efficacy, and follow-up monitoring of TIPIC syndrome. This approach should be considered the preferred imaging modality.

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Author contributions

Mengke Zhang and Nan Li analyzed the data and wrote the manuscript. Nan Li reviewed the manuscript.

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Conflicts of Interest

All authors declare no conflicts of interest.

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