

MINI-FOCUS ISSUE: CORONARY INTERVENTIONS

INTERMEDIATE

CASE REPORT: CLINICAL CASE

Utilizing Provocative Maneuvers Intraoperatively in Conjunction With IVUS to Diagnose vTOS



The New Gold Standard

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ABSTRACT

Current methodologies of diagnosing and managing venous thoracic outlet syndrome (vTOS) remain controversial, as pertinent studies using modern advancements in medicine are limited. We present a case in which we innovatively used a modified Wright's test during venography coupled with intravascular ultrasound, which allowed us to definitively determine the etiology of a vTOS. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2022;4:950-954) © 2022 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Paget-Schroetter syndrome (PSS), also known as venous thoracic outlet syndrome (vTOS), is a rare sequela of thoracic outlet syndrome (TOS) characterized by axillo-subclavian venous

thrombosis and can be a life-threatening complication, if left untreated. These thrombi are generally secondary to anatomic abnormalities at the costoclavicular space, the scalene triangle, or at the subcoracoid/sub-pectoralis minor space. They account for 5% of all cases of venous thromboemboli.¹ Special provocative tests, such as the Adson, Wright, and Roos, are commonly used by clinicians to help diagnose arterial TOS, but unfortunately, they are not reliable for venous or neurologic TOS. In addition, these tests are considered positive only if symptoms are reproduced. However, in many patients with venous TOS, the symptoms tend to be persistent, and performing these tests may not necessarily exacerbate them, resulting in high rates of false negatives.² Unlike TOS itself, the specific diagnosis of PSS cannot be made solely based on clinical evaluation. Conventional venography is an effective and

LEARNING OBJECTIVES

- To understand the utilization of provocative maneuvers such as Wright's and/or their modified variations intraoperatively during venography and thrombectomy.
- To comprehend the pivotal role of intra-procedural IVUS to evaluate venous thoracic outlet syndrome.
- To consider utilization of intraprocedural provocative maneuvers simultaneously with IVUS as a method to understand the anatomic etiologies of venous thoracic outlet syndrome.

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accurate tool that interventionalists may use to visualize and determine the exact site of the chronic total occlusion (CTO) in PSS; however, it does little in revealing the etiology of compression.³ In this report, we demonstrate how the innovative utilization of special provocative tests such as the Wright abduction test during interventional thrombectomy and balloon venoplasty with the use of intravenous ultrasound (IVUS) can definitively diagnose mechanical obstructive etiologies such as cervical rib compression. This is crucial to the care of these patients, as they may require urgent scalenectomy, resection of the first rib, and/or circumferential venolysis.

HISTORY OF PRESENTATION

A previously healthy 21-year-old man presented to the emergency room with the chief complaint of swelling, cyanosis, and tenderness in his right upper extremity after letting his significant other rest her head on his abducted shoulder for several hours overnight. He described the pain to be mild and associated with a feeling of “heaviness.” He denied recent participation in sports, repetitive activities, and trauma to the shoulder. He had no prior surgeries or central venous cannulation. He was subsequently started on Eliquis and discharged home with an outpatient follow-up with hematology, where a full hypercoagulability workup was unremarkable. His condition failed to improve, and 6 months later, he was referred to us for evaluation and more definitive management. By this time, his entire arm had turned purplish-blue with very prominent swelling. He reported that his arm was feeling very heavy with the dull throbbing pain still present. Significant venous tributaries were seen superficially, worse with elevation of the right upper extremity.

DIFFERENTIAL DIAGNOSIS

Venous thoracic outlet syndrome (Paget-Schroetter syndrome), deep vein thrombosis, cervical radiculopathy, brachial plexus injury, acromioclavicular joint injury, cervical disc injury, clavicular fracture, shoulder impingement syndrome, thoracic discogenic pain syndrome.

INVESTIGATIONS

Adson, Wright, and Roos tests were initially negative, showing no numbness/tingling or worsening cyanosis in the arm with manipulation; however, a subsequent venous Doppler ultrasound was performed that showed a subclavian occlusion (Figure 1). The etiology

of the occlusion remained a mystery, however, until use of our innovative approach discussed as follows.

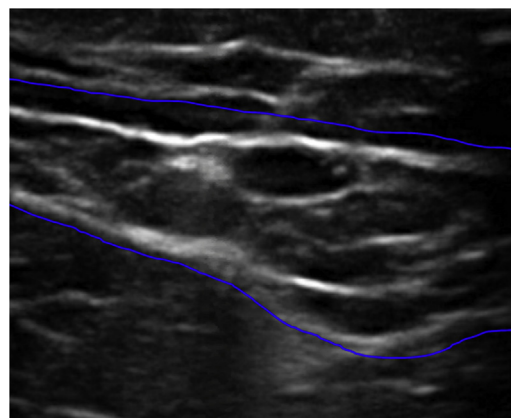
MANAGEMENT

Based on the findings, lack of hypercoagulability, and no other predisposing factor, our patient was referred to us for venography and thrombectomy. A venogram was done that delineated a CTO of the subclavian vein with robust collaterals from the cephalic and axillary veins into the superior vena cava (Figure 2). (See Figure 3 for visualization of the CTO on IVUS.) Despite our best attempts, no antegrade recanalization was feasible from the brachial vein because of a well-formed and smooth concave cap of the CTO. Thus, we obtained right femoral venous access and were able to penetrate the cap and cross the CTO into the true lumen of the axillary vein. We performed mechanical thrombolysis and thrombectomy (Angiojet, Boston Scientific), followed by venoplasty with a 10.0-mm semi-compliant balloon. Thereafter, we elected to leave the balloon partially inflated in place and had a member of our team reach under the sterile field and abduct our patient’s arm, which demonstrated compression of the balloon mimicking the same compression of the vein, essentially confirming the diagnosis (Figure 4). We then took the maneuver 1 step further by inserting an IVUS catheter at the level of compression and performed the same abduction maneuvers, which resulted in complete obliteration of the vein (Figure 5). We then used a 14.0-mm Armada balloon and performed venoplasty once again in a 1:1 fashion to help ensure patency (Figure 6). Once complete, all sheaths were removed

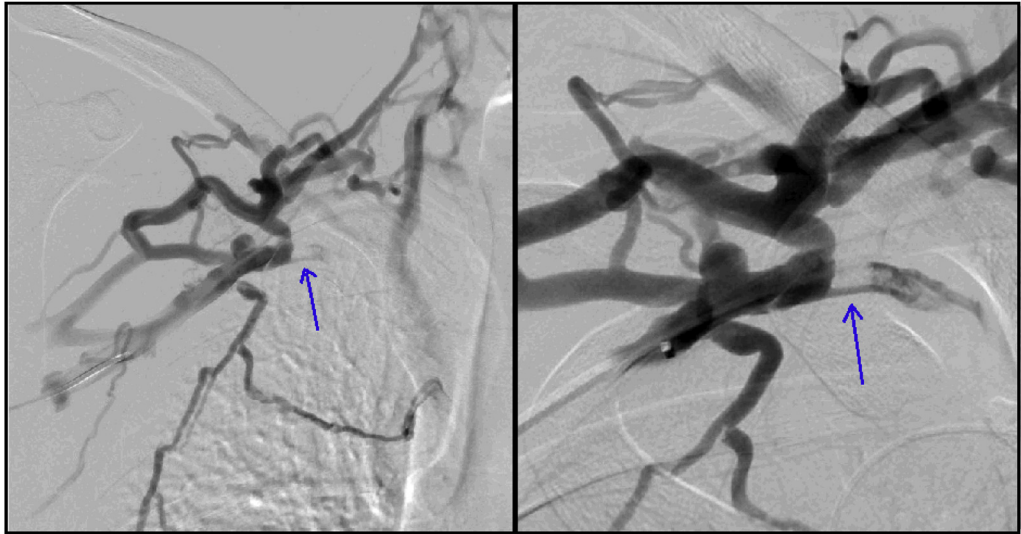
ABBREVIATIONS AND ACRONYMS

- CTO = chronic total occlusion
- IVUS = intravascular ultrasound
- PSS = Paget-Schroetter Syndrome
- TOS = thoracic outlet syndrome
- vTOS = venous thoracic outlet syndrome

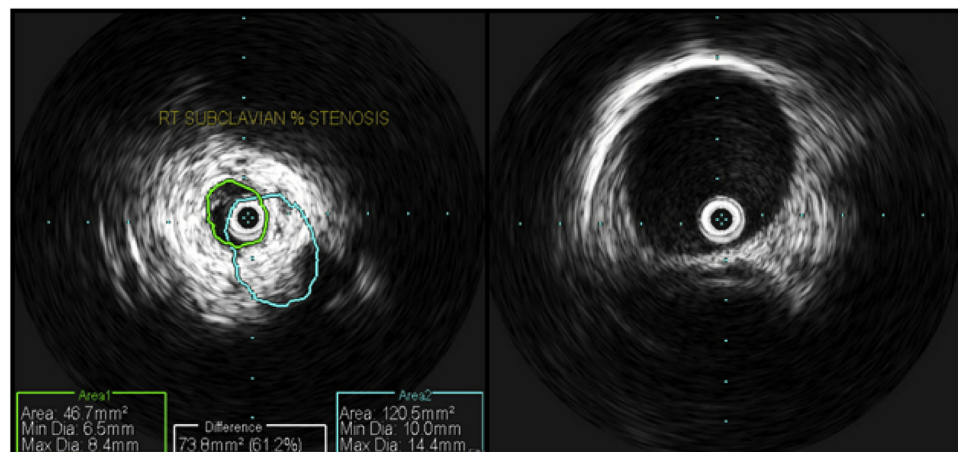
FIGURE 1 Longitudinal View of Subclavian Vein Thrombosis Seen on Doppler Ultrasound



showed a subclavian occlusion (Figure 1). The etiology

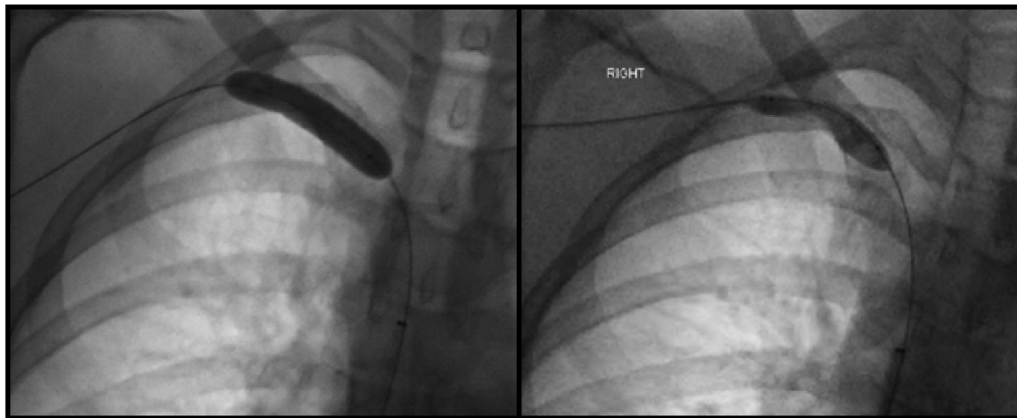
FIGURE 2 Large Right Subclavian Chronic Total Occlusion Seen on Venogram

Contrast was injected from the right brachial vein. The images were captured with visualization of collaterals. **Blue arrows** denote the thrombotic occlusion of the subclavian vein.

FIGURE 3 Intravascular Ultrasound Visualizations of the Right Subclavian Vein Patency Pre- and Post-Intervention

Axial views of the right subclavian vein showing diffuse echodense calcified plaques consistent with intimal disease and venous thrombi seen on intravascular ultrasound before intervention (**left**) followed by successful recanalization status-post mechanical thrombectomy and balloon angioplasty (**right**).

FIGURE 4 Visualization of the Armada Balloon on Fluoroscopy Before and After Provocative Maneuver(s)



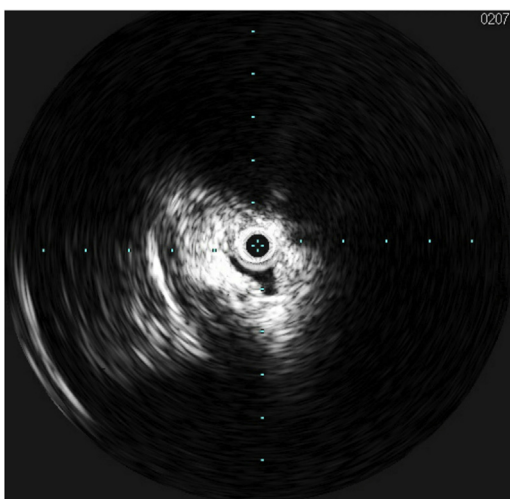
Low-dose fluoroscopy showing a 10.0 mm × 40 Armada balloon inflated in the right subclavian vein following mechanical thrombectomy before (**left**) and after (**right**) intraoperative abduction of the shoulder. This maneuver revealed a mechanical obstruction of the vessel at the level of the first rib.

and patient was referred for first rib resection related to vTOS. He underwent the surgery without any complications and continues to do well to this day 6 months later.

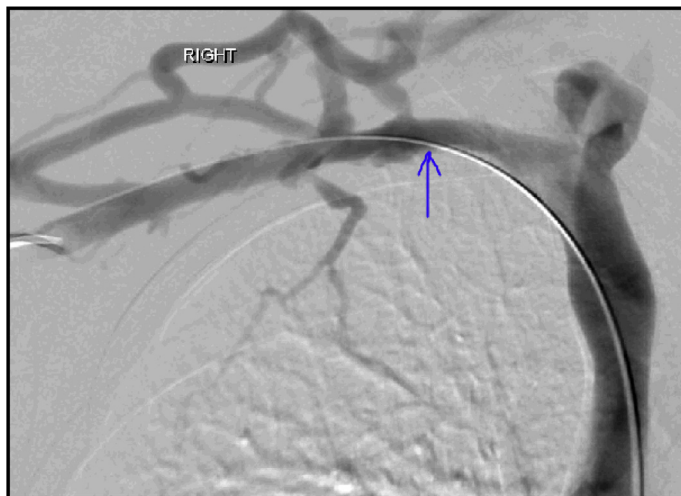
DISCUSSION

The diagnosis of TOS in general has always been one of exclusion and based on thorough history taking, physical examination, and imaging. Special tests, such as Adson, Wright, and Roos, have always been used by clinicians but remain very inaccurate tests. Of these 3 special tests, the Wright test has shown to be the most sensitive at only 78% to 85%, and the Adson has been shown to be the most specific at 70% to 90%.² Additional tests such as Doppler ultrasounds or nerve conduction studies are frequently subsequently ordered. In this case, we were able to determine a venous TOS based on Doppler ultrasound. Once we committed to intervention with thrombectomy and venoplasty, we were able to definitively confirm the diagnosis with IVUS and venography; however, it was not until our unique utilization of a modified Wright test during intervention when we were able to also determine the true underlying etiology. When it comes to vTOS, most clinicians would agree that venography remains the mainstay for visualizing the location of occlusion. With the latest introduction and utilization of IVUS, we now know that venography alone is not sufficient. In a study performed by Kim et al⁴ at Yale University, IVUS detected significant venous stenosis in 94.4% of patients compared with 66.7% of patients in whom venography alone was used. Several other studies have proven to show comparable results. We believe the use of an incompletely inflated balloon

FIGURE 5 Intravascular Ultrasound Visualization of Near-Total Compression of the Right Subclavian Vein During Provocative Maneuver(s)



Intravascular ultrasound showing an axial view of the right subclavian vein after successful recanalization status-post mechanical thrombectomy and balloon angioplasty but with the patient's arms abducted, resulting in compression of the vein at the level of the first rib and thus near total loss of lumen.

FIGURE 6 Successful Recanalization of the Right Subclavian Vein

Venogram demonstrating successful recanalization with a patent subclavian vein draining into the superior vena cava status-post mechanical thrombectomy and balloon dilation. **Blue arrow** denotes the prior site of occlusion.

or the use of IVUS placed at the level of compression coupled with provocative maneuvers mid-intervention clearly, accurately, and definitively provides the diagnosis of vTOS and provides rationale and justification for seeking a definitive surgical therapy rather than a temporizing one, such a thrombectomy or venoplasty.

FOLLOW-UP

Our patient is now 6 months status-post thrombectomy and first rib resection and continues to do well without any reoccurrence of his vTOS.

CONCLUSIONS

We believe the use of the Wright test or its modified variations during intervention with simultaneous IVUS significantly increases the accuracy in determining the etiology of PSS or vTOS, especially when it is secondary to a mechanical anatomic obstruction. As of now, the approaches to diagnosing and managing TOS continue to remain variable and controversial. However, we believe this approach has the potential to serve as the new gold standard. Additional studies will be needed to help validate this claim.

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KEY WORDS IV ultrasound, thrombectomy, vTOS