The infraclavicular approach for Paget–Schroetter syndrome

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ABSTRACT

INTRODUCTION Paget–Schroetter syndrome is a rare effort thrombosis of the axillary-subclavian vein, mainly occurring in young male patients. Current management involves immediate catheter directed thrombolysis, followed by surgical decompression of the subclavian vein. This has been invariably performed using a transaxillary or supraclavicular approach. However, the subclavian vein crosses the first rib anteriorly just behind the manubrium and can also be accessed via an infraclavicular incision.

METHODS MEDLINE® and Embase™ were searched for all studies on outcomes in patients undergoing infraclavicular first rib resection for treatment of Paget–Schroetter syndrome. Measured outcomes included freedom from reintervention, secondary patency and symptom resolution. Studies on neurogenic, arterial and iatrogenic venous thoracic outlet syndrome were not included.

FINDINGS Six studies (involving 268 patients) were eligible. The overall secondary venous patency rate was 98.5%. There was freedom from reintervention in 89.9% of cases and among those patients with reocclusion, 84.0% had chronic thrombosis (symptom duration >14 days), with 76.2% having a venous segment stenosis of >2cm. Only 3 of the 27 patients remained occluded despite reintervention.

The infraclavicular approach provides excellent exposure to the subclavian vein and allows reconstruction when required. Moreover, this approach enables complete resection of the extrinsic compression that precipitated the initial thrombotic event, with excellent long-term patency rates. In conclusion, the infraclavicular route may have significant advantages compared with the transaxillary or supraclavicular approaches for successful and durable treatment of Paget–Schroetter syndrome.

KEYWORDS

Paget–Schroetter syndrome – Effort related upper extremity deep vein thrombosis – Idiopathic upper extremity deep vein thrombosis – Venous thoracic outlet syndrome

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Paget–Schroetter syndrome (PSS) is a thrombosis of the axillary-subclavian vein (SV), due to repetitive use of the arm associated with ‘the presence of one or more compressive elements in the thoracic outlet’.¹ The condition is more often seen in male patients (with a male-to-female ratio of 2.1:1 reported in the literature) and accounts for 1–4% of all cases of venous thrombosis.²

Current management for PSS is catheter directed thrombolysis and decompression of the SV by first rib resection. The key to successful treatment of PSS is a thorough understanding of the anatomy and structures that impinge on the SV causing extrinsic compression. The subclavius muscle and tendon are located medially, creating the potential for a nutcracker-like compression of the SV with minimal movement.³ The costoclavicular ligament inserts inferiorly to the upper medial aspect of the first rib and posterolaterally to the tuberosity on the inferior aspect of the medial clavicle.

Historically, the thoracic outlet has been decompressed using the transaxillary (TA) or supraclavicular approach.

Both provide excellent access for surgical decompression of the brachial plexus and subclavian artery. The SV is located anteriorly, posterior to the manubrium, and this explains why an infraclavicular (IC) incision may be an appropriate alternative option for surgical management of PSS.

Methods

A systematic search of the literature was conducted using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Fig 1).⁴ MEDLINE® and Embase™ were searched up to September 2016 for all publications regarding the IC approach and outcomes for PSS. Table 1 shows the search terms used to identify all appropriate publications for each search criterion.

In order to be included in the review, the studies had to describe outcomes in patients undergoing IC first rib resection. Owing to the different aetiology and compression

mechanism, studies concerning arterial, neurogenic or iatrogenic venous thoracic outlet syndrome were excluded. Duplicate cohorts of patients treated at the same institution and reported in more than one study were identified and excluded.

Measured outcomes included freedom from reintervention, secondary patency and symptom resolution. Secondary patency refers to venous patency following postoperative reintervention such as stenting or balloon venoplasty.

Results

Of the 829 publications that were screened initially, 726 were excluded based on their abstract, which did not meet the inclusion criteria. The full text of the remaining 100 publications and 3 conference abstracts was assessed by the authors. Of these, six full papers were eligible for final review.

Six studies (including 268 patients with PSS) published between 1998 and 2016 adopted an IC approach to surgical decompression of the SV (Table 2).⁵⁻¹⁰ Of these, one study was prospective, three were retrospective and two were case

series. There were no randomised controlled studies. The largest study, by Molina *et al* in 2009, reported on 207 patients over a period of 24 years.⁹ The mean study length for the four cohort studies was 10.8 years.^{5-7,9} Two hundred and twenty-one patients (82.5%) were treated at one institution while the remaining forty-seven were managed at three other centres. The mean age was 30.8 years in five of the studies, with a male to female ratio of 1.3:1 (*n*=176).^{5,6,8-10}

Diagnosis and preoperative management

Venography was used to confirm the diagnosis of SV thrombosis in two of the studies and ultrasonography in another (Table 3).^{5,8,9} The remaining three did not mention the diagnostic imaging used. There were no cervical ribs in any of the patients.

All patients underwent catheter directed thrombolysis, with 14 (5.2%) undergoing pharmacomechanical thrombolysis (PMT).^{5,7} Eighty-six patients (34.3%) received thrombolysis more than two weeks after the initial thrombotic event (*n*=251).^{5,6,9,10}

Nineteen patients (5.2%) re-presented with recurrent symptoms following previous interventions for their PSS at

Figure 1 Flowchart of studies included in review

Table 1 Search terms used in MEDLINE® and Embase™

1	exp Upper Extremity Deep Vein Thrombosis/
2	Paget Schroetter syndrome.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
3	subclavian vein thrombosis.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
4	effort thrombosis.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
5	venous thoracic outlet syndrome.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
6	1 or 2 or 3 or 4 or 5
7	exp General Surgery/
8	surg*.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
9	infraclavicular.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
10	7 or 8 or 9
11	6 and 10

different institutions.^{8,9} The time interval between primary intervention and reoperation using an IC approach ranged from 5 months to 7 years (mean: 25.4 months) in ten of these patients and ‘months’ in four other patients (interval not otherwise specified).^{8,9} All of them had undergone TA first rib resection, alongside 35 balloon venoplasty interventions and 14 stent insertions.^{8,9} Five of the nineteen (26.3%) were deemed unsuitable for repeat surgical intervention via an IC approach owing to venous stenosis, as early as fourteen days after TA surgery (range: 2 weeks – 11 months).⁸ Among the 254 patients (94.8%) undergoing treatment for their PSS for the first time, preoperative balloon venoplasty alone (no stent insertion) was performed in four cases (1.6%).⁵

Surgical treatment

The mean time interval from the thrombotic event to surgery was <14 days in 133 patients (49.6%). All patients underwent first rib resection, anterior scalenectomy and removal of the subclavius muscle tendon via an IC incision.

Table 4 summarises the intraoperative approach and outcomes for the six studies reviewed. Intraoperative balloon venoplasty was performed in 32 patients (11.9%), with stent insertion in 15 (5.6%).^{6,7,8,10} Six stents were placed in patients who had already had one implanted elsewhere and six others were used in chronic patients re-presenting after failed TA rib resection (weeks or months after resection in four patients who underwent venography owing to persisting oedema, with two of these having more than one stent inserted).⁶⁻⁸ The remaining three stents were placed because of residual occlusion assessed on intraoperative venography immediately after surgical decompression.⁶⁻⁸ Siracuse *et al* and Spivack *et al* used intraoperative venography in 40 patients (14.9%) to exclude venous reocclusion following decompression.^{6,7}

Venous reconstruction was performed in 219 patients (81.7%).^{5,8-10} In the majority ($n=203$, 92.7%), a vein patch was used to reconstruct the affected venous segment.^{5,8-10} A thoracic aortic homograft patch was used in 15 patients (6.8%) and an interposed aortic homograft in 1 patient

Table 2 Summary of the studies included in the review

Study	Study design	Length of study	Number of patients	Male-to-female ratio	Mean age
Kärkkäinen, 2016 ⁵	Prospective cohort	5 years	7	6:1	35 years
Siracuse, 2015 ⁶	Retrospective cohort	8 years	33	20:13	35 years
Spivack, 2013 ⁷	Retrospective cohort	6 years	7	Not specified	Not specified
Molina, 2011 ⁸	Case series	–	10 ^a	3:7	31 years
Molina, 2009 ⁹	Retrospective cohort	24 years	207	69:57 (group I)	29 years (group I)
Molina, 1998 ¹⁰	Case series	–	4	Not specified	24 years

^aAn additional 5 patients were deemed inoperable following failed transaxillary first rib resection.

Table 3 Preoperative management

Study	Number of patients	Mean time from symptom onset to thrombolysis	Diagnostic imaging	Length of venous stenosis	Thrombolysis: PT ^a / PMT ^b	Surgical approach	Time from initial thrombotic event to surgery	Preoperative balloon venoplasty +/- stenting
Kärkkäinen, 2016 ⁵	7	<14 days (n=6) 14–28 days (n=1)	Ultrasonography	Subclavian, <10cm (n=3) Axillary-subclavian, 10–20cm (n=3) Basilic/cephalic-subclavian, >20cm (n=1)	PMT (n=7)	IC	Mean 11 days	Venoplasty (n=4)
Siracuse, 2015 ⁶	33	<14 days	Surgical approach	Not specified	PT (n=33)	IC + intraoperative venography	Mean 39 days (range: 1–days)	n=0
Spivack, 2013 ⁷	7	Not specified	Surgical approach	Not specified	PMT (n=7)	IC + intraoperative venography	Mean: 29 days (range: 0–104 days)	n=0
Molina, 2011 ⁸	10 (+5 inoperable)	Not specified (previous TA surgery +/- stent)	Venography	Not specified	PT (n=10)	IC + transsternal extension for previously implanted long segment ^c stents (n=2)	Mean 23.4 mths following TA rib resection (range: 5 mths – 7 yrs)	Venoplasty (n=35) + stents (n=7) at different institutions
Molina, 2009 ⁹	207	Group I: <14 days (n=126) Group II: >14 days (n=81, incl 4 with previous TA + stent)	Venography	Group I: not specified Group II: >2cm (n=32) <2cm (n=49)	PT (n=207)	IC + transsternal extension for long segment ^c stenosis (n=32)	Group I: <14 days Group II: >14 days	7 stents inserted at different institution (chronic long segment ^c patients)
Molina, 1998 ¹⁰	4	>14 days	Not specified	>2cm (subclavian-innominate)	PT (n=4)	IC + transsternal extension (n=4)	>14 days	n=0

IC = infraclavicular; PMT = pharmacomechanical thrombolysis; PT = pharmacological thrombolysis; TA = transaxillary

^aPT refers to catheter directed infusion of thrombolytic agent.

^bPMT involves mechanical dispersion of thrombus with a single bolus of thrombolytic agent.

^cVenous stenosis length >2cm

(0.5%).^{5,8–10} One of the patients who had a vein patch reconstruction had suffered an intimal tear caused by PMT.⁵

Of the 268 patients included in the studies in our review, 38 patients (14.2%) with a stenosed vein segment of >2cm, operated on by Molina *et al*, had a transsternal extension of the IC incision to allow access to the axillary-subclavian-innominate vein segment for reconstruction.^{8–10} At reoperation of all 14 patients previously decompressed via a TA approach, an intact anterior segment of the first rib was found, as were an intact costoclavicular ligament and subclavius tendon, all compressing the SV.^{8,9}

Freedom from reintervention

Twenty-seven patients (10.1%) required reintervention for reocclusion, namely stenting (n=22), repeat PMT with stenting (n=2), repeat PMT with balloon venoplasty (n=1), repeat PMT only (n=1) and balloon venoplasty only (n=1).^{5–7,9} The symptom duration prior to surgery was >14 days in 84.0% of cases (n=21/25), with a venous stenosis length of >2cm in 76.2% of these (n=16/21).^{5,9} Venous reconstruction had been performed in 81.5% of the patients (n=22/27).^{5,6,9} Three of the patients who required reintervention had previously had TA venous decompression plus stent insertion at different institutions.⁹

Of the 27 patients, 3 (11.1%) remained occluded.⁹ All had chronic long segment venous stenosis with previous venous reconstruction using a thoracic aortic homograft (n=2) or vein patch (n=1).

Symptom resolution

Resolution of symptoms in the limb affected by PSS was reported in 98.9% of cases.^{5–10} Three patients who had presented with chronic thrombosis remained occluded despite reintervention.⁹

Secondary patency and duration of follow-up period

The secondary patency rate was 98.5% and patency was assessed on duplex ultrasonography, apart from in one case, where the patient underwent venography at the two-month follow-up visit.^{5–10} The follow-up duration in the largest study (by Molina *et al* in 2009) ranged from 6 months to 25 years, with 66 of the 207 patients having a patent SV beyond five years.⁹ In the study by Siracuse *et al*, the follow-up period ranged from 2–483 days (median: 78 days)⁶ and in the case series reported by Molina in 2011, it was 6 months to 5 years.⁸ The mean follow-up duration for the remaining three studies was 23 months.^{5,7,10}

Discussion

Reliable evidence concerning the optimum approach for the surgical treatment of PSS is lacking in the literature. In the UK, a survey of 60 members of the Vascular Surgical Society in 2004 found less than two-thirds considered surgical decompression an appropriate intervention for PSS.¹² If decompression was performed, 4% chose a paraclavicular approach (two incisions: one above and another below the

Table 4 Intraoperative approach and outcomes

Study	Intraoperative balloon venoplasty +/- stenting	Venous reconstruction	Postoperative complications	Postoperative reintervention for reocclusion	Freedom from reintervention	Symptom resolution	Secondary patency ^a	Follow-up duration	Method of follow-up
Kärkkäinen, 2016 ⁵	<i>n</i> =0	Patch venoplasty (<i>n</i> =3)	<i>n</i> =2 (haemothorax and vein harvest wound haematoma)	Stenting (<i>n</i> =2) (patch venoplasty patients)	71% (<i>n</i> =5)	100% (<i>n</i> =7)	88% (<i>n</i> =6)	Mean 25 ±17 mths	Ultrasonography (<i>n</i> =5) Venography (<i>n</i> =1) 1 patient had no follow-up (asymptomatic at 1 mth)
Siracuse, 2015 ⁶	Venoplasty (<i>n</i> =23)	<i>n</i> =0	<i>n</i> =1 (haemothorax)	<i>n</i> =3: repeat PT (<i>n</i> =2) and venoplasty (<i>n</i> =2)	91% (<i>n</i> =30)	100% (<i>n</i> =33)	100% (<i>n</i> =33)	Median 78 days (range: 2–483 days)	Ultrasonography (1 patient lost to follow-up)
Spivack, 2013 ⁷	Venoplasty + stenting (<i>n</i> =3)	<i>n</i> =0	<i>n</i> =0	<i>n</i> =2 (initial intraoperative venoplasty): repeat PMT + stenting	71% (<i>n</i> =5)	100% (<i>n</i> =7)	100% at mean 30 mths (<i>n</i> =7)	1 week, 3 mths, 6 mths and annually	Ultrasonography
Molina, 2011 ⁸	6 stents inserted at different institutions replaced + 6 new stents inserted	Vein patch (<i>n</i> =10)	<i>n</i> =0	<i>n</i> =0	100% (<i>n</i> =10)	100% (<i>n</i> =10)	100% (<i>n</i> =10)	6 mths – 5 yrs	Ultrasonography at 6 and 12 wks
Molina, 2009 ⁹	<i>n</i> =0	Group I: vein patch (<i>n</i> =126) Group II: • vein patch for short segments ^b (<i>n</i> =44) • thoracic aortic homograft for long segments ^c (<i>n</i> =14) • long vein patch (<i>n</i> =18)	Group I: ^d <i>n</i> =5/97 (bleeding x1, pneumothorax x2, lymphocele x2) Group II: ^d not specified	Group I: <i>n</i> =0 Group II: • short segment: ^b 5 stents • long segment ^c homograft: 4 stents • long vein patch: 11 stents (incl 3 previous TA + stent)	Group I: 100% (<i>n</i> =126) Group II: 75% (<i>n</i> =61)	Group I: 100% (<i>n</i> =126) Group II: 96% (<i>n</i> =78)	Group I: 100% (<i>n</i> =126) Group II: • 100% short segment ^b (<i>n</i> =44) • 86% homograft (<i>n</i> =12) • 94% long vein patch (<i>n</i> =17)	Group I: 6 mths – 25 yrs Group II: 6 mths – 18 yrs	Ultrasonography before discharge, at 2 wks, 1 mth and 3 mths
Molina, 1998 ¹⁰	<i>n</i> =0	Vein patch (<i>n</i> =2) Interposed aortic homograft (<i>n</i> =1) Homograft	<i>n</i> =0	<i>n</i> =0	100% (<i>n</i> =4)	100% (<i>n</i> =4)	100% (<i>n</i> =4)	Mean 12 mths (range: 6–14 mths)	Ultrasonography

PMT = pharmacomechanical thrombolysis; PT = pharmacological thrombolysis

^aSecondary patency refers to postoperative venous patency following reinterventions for rethrombosis.

^bVenous stenosis length <2cm

^cVenous stenosis length >2cm

^dReported by Molina *et al* in 2007¹¹ (cohort of 102 patients included in the study published in 2009)⁹

vicular approach. The remaining 13% preferred a combined TA and supraclavicular route.

Reasons for this disparity may in part be traced back to one of the first published series concerning operative treatment of thoracic outlet syndrome in 1966 by Roos.¹⁵ This large series proposed a TA approach for decompression. The majority of patients underwent treatment for neurological and arterial symptoms with little discussion regarding the specific treatment of PSS. Subsequently, the TA approach was adopted by many surgeons to treat all causes of thoracic outlet syndrome as undoubtedly excellent exposure is achieved to the cervical and first ribs with no visible scar.¹⁴

Another reason why the IC route never became the first-line approach was the possibility of trauma to pectoralis major muscle fibres. As many cases occurred in competitive

training. However, Siracuse *et al* proposed that access to the first rib need not require incision of the pectoralis major fibres as access can be gained by working between the muscular fibres.⁶

A clear understanding of the venous anatomy at the thoracic outlet is mandatory for optimum long-term results from surgical decompression. The importance of access to the medial aspect of the SV was reported by Molina *et al* in 2009.⁹ They concluded that owing to persistent extrinsic compression by a residual first rib stump anteriorly, many re-present with thrombosis of the SV. Together with an incomplete resection of the costoclavicular ligament and/or the tendon of the subclavius muscle, this may cause early recurrence of the problem. Over 5% of patients in this review presented with recurrent thrombosis following

Table 5 Studies with TA and SC approaches for venous thoracic outlet decompression									
Study	Approach	Number of patients	Thrombolysis	Acute / chronic thrombosis ^a	Venous reconstruction	Balloon venoplasty +/- stenting	Patency rate ^b	Full function	
Stone, 2010 ¹⁵	TA	19	83%	Acute and chronic	Not performed	Intraoperative patch venoplasty (n=4)	Primary: 100% at 1 yr 77.4% at 5 yrs	86% overall	
	SC IC	11 6				Stenting: 1 preoperative 8 intraoperative 2 postoperative	Secondary: 100% at 1 yr 94% at 5 yrs		
Guzzo, 2010 ²⁰	TA	110	extremities	Group I (n=45): yes Group II (n=65): no	Chronic	Not performed	Preoperative balloon venoplasty (n=20) Postoperative balloon venoplasty (n=36)	Primary 35% Secondary 91% at 1 yr Primary 23% Secondary 91% at 14.5 mths	96% 98%
	TA	67	Yes		Not performed		Secondary 96% overall at 10 mths (median) Secondary 100% at 7 mths Secondary 100% at 11 mths Primary 82%	96% overall 100% 100% 100%	
de León, 2009 ²¹			Group I (n=3)	Acute		Postoperative venoplasty (n=1)			
			Group II (n=39)	Chronic		Postoperative venoplasty (n=25)			
			Group III (n=11) obstruction without thrombosis	Chronic		Postoperative venoplasty (n=2)			
			Group IV (n=14)	Chronic		Not performed			
Urschel, 2008 ²²	TA	626	extremities		No patch/graft		No VG to establish long-term patency		
			Group I (n=21): no	Not specified	Thrombectomy (n=8)	Not performed	One recurrence	29% ^c	
			Group II (n=25): yes	Not specified	Thrombectomy (n=4)	Not performed	No recurrence	100%	
			Group III (n=506): yes Group IV (n=42): yes	<6 wks >6 wks	Thrombectomy (n=2) Not performed	Not performed	No recurrence	96%	
						Postoperative bypass graft (n=3)	Primary 57%	57%	

Lee, 2006 ²³	SC	37	Yes	Chronic	Not performed	Balloon venoplasty (in ~50%) Balloon venoplasty (n=4) Preoperative stenting (n=2)	97% at 51 mths (mean) 100% at 51 mths (mean)	93% at 51 mths (mean) 100%
Maxey, 2003 ¹⁸	SC only (n=7) SC + IC (n=3)	10	Not specified	Not specified	Not specified	Not specified	Not specified	80% at 14–24 mths
Kreienberg, 2001 ²⁴	SC: Scalenectomy (n=23) First rib resection (n=16)	23	Yes	Acute (<30 days from onset)	Not performed	Intraoperative venoplasty (n=23)	100% at 4 yrs (mean)	100%
Lee, 2000 ²⁵	SC	13	Yes	Chronic	Not performed	Not performed	Primary 92% Secondary 100% at 22.3 mths (mean)	85%
Lee, 1998 ²⁶	SC: Partial first rib resection + scalenectomy (n=9) Scalenectomy only (n=2)	11 extremities	Yes	Acute	Vein patch (n=3) Bypass (n=2)	Preoperative venoplasty (n=5)	Primary 64%	89%
Azaki, 1998 ¹⁹	SC (n=9) SC + IC (n=21) TA (n=1) TA + IC (n=1)	34 extremities	81%	Acute (n=21)	Jugular subclavian vein bypass graft (n=1) Vein patch angioplasty (n=2)	Preoperative venoplasty (n=7) + 1 stent Postoperative venoplasty (n=4)	Not specified	100% at 31 mths (mean)
Machleder, 1993 ²⁷	TA	36	Yes	Chronic	Not performed	Preoperative balloon venoplasty (n=12) Postoperative balloon venoplasty (n=9)	Primary 64% Secondary 94% at 3.1 yrs (mean)	83%
Urschel, 1991 ²⁸	TA	56 extremities	Group 1 (n=21): no Group 2 (n=35): yes	Chronic	Thrombectomy (n=8) No patch/graft Thrombectomy (n=4) No patch/graft	Not performed	No follow-up VG	29% ^c at 7–25 yrs
IC = infraclavicular; SC = supraclavicular; TA = transaxillary; VG = venography ^a Acute refers to <14 days after symptom onset while chronic refers to >14 days after symptom onset ^b Primary patency refers to postoperative venous patency prior to any reinterventions for rethrombosis while secondary patency refers to postoperative venous patency following reinterventions for rethrombosis. ^c Includes patients treated conservatively								

inadequate TA rib resection.^{8,9} This could have medicolegal implications when inadequate initial decompression leads to rethrombosis requiring reintervention.

There is evidence of increasing use of the IC approach for PSS with five recent studies modifying their TA or supraclavicular approach by incorporating an additional or separate IC incision.^{15–19} As these studies did not report outcomes for IC approach alone, they were not included in the final analysis but remain valuable in reflecting current attitudes on its use to treat PSS. A long series studied over 20 years and reported in 2010 showed a similar transition from the TA to the supraclavicular approach, followed by the IC approach in their most recent 6 patients treated for SV thrombosis.¹⁵ This is similar to a later study in 2013 that witnessed a transition to the IC approach.⁷

Although our review focuses on the use of the IC approach to treat PSS, Table 5 describes the larger studies using the TA or supraclavicular routes.^{15,18–28} There have been no randomised prospective studies comparing the three approaches. In the largest series of patients (studied over a period of 50 years), TA surgery was performed (at <6 weeks from symptom onset) and 486 of the 506 patients improved.²² However, no venography was carried out to establish long-term postoperative patency. No venous reconstruction was undertaken in any of these TA procedures as medial dissection of the SV may be problematic.

Over 80% of the patients in the reviewed studies underwent SV reconstruction; Molina in particular adopted an aggressive approach to treatment by vein patch or even homograft replacement.^{5,8–10} He also had a low threshold for transsternal extension of the incision for medial access to the SV, with over 10% of his patients undergoing this.^{9,10} Overall, more than 10% of SVs reoccluded after surgery and required reintervention.^{5–7,9} Factors predisposing to poor clinical outcomes included vein stenosis >2cm and time from presentation to surgical decompression >14 days.^{5,9} There is little to support the use of preoperative balloon venoplasty, with stents used in 5% of the cases in our review.^{8,9}

Exactly which patients may benefit from venous reconstruction is difficult to ascertain. Following adequate venous decompression and importantly venolysis, many may well benefit from venoplasty and a period of anticoagulation. If lysis and outlet decompression are performed early, primary and secondary venous patency rates are excellent, with the majority having full resolution of their symptoms. Reinterventions for reocclusion occurred in 10% while those remaining occluded represented those with long segment stenosis (>2cm).^{5–7,9}

Conclusions

The IC approach allows complete resection of the anterior first rib, subclavius muscle and costoclavicular ligament. This eliminates the extrinsic compression that precipitated the initial thrombotic event, with excellent long-term patency rates. At present, evidence is lacking as to which patients may benefit from venous reconstruction but the IC approach enables this to be performed as medial access is

easily obtained for control. Symptom duration of >14 days and venous segment stenosis of >2cm appear to be predisposing factors for reocclusion requiring reintervention.

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