Vascular injuries associated with paddle tennis. Paget-Schroetter Syndrome

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Summary

Introduction: Padel is a young sport that attracts millions of people, of both sex, all ages and social status. Practicing padel brings numerous health benefits, but it can also induce injuries.
Objectives: To analyze the relationship between vascular and padel pathology, and present the most significant aspects of Paget-Schroetter syndrome, and relate them to padel.
Methodology: Literature review, until August 1, 2019, in PubMed, Google and specialized Spanish journals; and presentation of a clinical case.
Results: The search did not find any reference between padel and vascular pathology, but I identify 20 articles that relate racket sports and vascular pathology, to infer some of its aspects to padel. Clinical case: A 34-year-old male, a regular padel practitioner, diagnosed (echo-Doppler) with a right axillary subclavian venous thrombosis (Paget-Schroetter syndrome); satisfactorily treated by local fibrinolysis (through catheter) and resection of the first rib (thoracoscopy). Currently asymptomatic and under oral anticoagulation.
Conclusions: 1) Little bibliography in this regard; 2) Low frequency of vascular complications during racquet sports; and 3) First case of the literature, of a Paget-Schoetter syndrome associated with padel player.
Practical consequences: 1) The mechanism of production is explained by the combination of triggers (repetition of shoulder movements, associated with forced positions - abduction of the arm), and predisposing factors (venous compression by anomalous anatomical structures); and 2) Think of this entity, mainly before young people, athletes, and without a pathological history; only early management prevents complications (pulmonary embolism), relapses and sequelae (post-thrombotic syndrome).

Key words:
Padel player. Tennis player. Racket sport. Vascular disorders. Venous disease. Venous thrombosis. Paget-Schroetter syndrome.

Lesiones vasculares asociadas a la práctica del pádel. El síndrome de Paget-Schroetter

Resumen

Introducción: El pádel es un joven deporte que atrae a millones de personas, de ambos sexos, de todas las edades y condición social. Practicarlo aporta numerosos beneficios para la salud, pero también puede inducir lesiones.
Objetivos: Analizar la relación patología vascular y pádel, y presentar los aspectos más significativos del síndrome de Paget-Schroetter, y relacionarlos con dicho deporte.
Metodología: Se realiza una revisión de la literatura, hasta el 1 de agosto del 2019, en PubMed, Google y revistas españolas especializadas; conjuntamente presentamos un caso clínico.
Resultados: La búsqueda realizada no encontró ninguna referencia entre pádel y patología vascular, pero identificó 20 artículos que relacionan deportes de raqueta y patología vascular, que nos permite inferir algunos de sus aspectos al pádel. Caso clínico: Varón de 34 años, practicante habitual de pádel, diagnosticado mediante eco-Doppler de una trombosis venosa axilo-subclavia derecha (síndrome de Paget-Schroetter); fue tratado satisfactoriamente mediante fibrinolisis local, a través de catéter, y posterior resección de la primera costilla (toracoscopia). Actualmente está asintomático y bajo anticoagulación oral.
Conclusiones: 1) Escasa bibliografía al respecto; 2) Baja frecuencia de complicaciones vasculares durante la práctica de los deportes con raqueta; y 3) Primer caso de la literatura, de un síndrome de Paget-Schroetter asociado al pádel.
Consecuencias prácticas: 1) El mecanismo de producción se explica por la combinación de factores desencadenantes (repetición de movimientos del hombro, asociados a posiciones forzadas - abducción del brazo), y predisponentes (compresión venosa por estructuras anatómicas anómalas); y 2) Pensar en esta entidad, fundamentalmente ante jóvenes, deportistas, y sin antecedentes patológicos; únicamente un manejo precoz evita complicaciones (embolia pulmonar), recidivas y secuelas (síndrome postrombótico).

Palabras clave:
Pádel. Tenis. Deportes de raqueta. Patología vascular. Enfermedades venosas. Trombosis venosas. Síndrome de Paget-Schroetter.

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Introduction

Paddle tennis is one of the most recently added sports in the racket and stick sports category (badminton, frontenis, tennis, table tennis, squash, etc.)[1]. Conceived as a sporting (amateur and professional) or leisure activity, each day more people - men and women of all ages - take up the sport. In this respect, a report about the sporting habits of Spanish people by the Spanish Sports Council and the Sociological Research Centre, in collaboration with the National Statistics Institute, revealed that in 2015, 4.2 million Spaniards played paddle tennis; some 3 million more than in 2010[2].

However, this growing participation in paddle tennis in Spain and other places around the world does not correlate with the number of scientific publications produced about paddle tennis and sports medicine. This fact contrasts with other sports, where the major North American leagues have particular prominence (American football, baseball, basketball and hockey)[3-4] or tennis[5-6].

We know that playing paddle tennis gives physical and psychological benefits (personal and social), and that it should also encourage healthy living habits[7]. There is also some data available about the negative side[8,9]. García-Fernández, *et al.*[9] have quantified 2.75 injuries per every 1,000 hours of exposure to the risk (similar percentage to the injury rate in other racket sports). Paddle tennis is considered a low static and high dynamic sport, entailing intense yet short bursts of effort; despite its similarity to tennis, it is less aerobic in nature. During the game of paddle tennis, hits and impacts are made and received repeatedly yet intermittently, on a hard surface (hybrid court, somewhere between racket/stick sports and wall and net sports), where numerous turns, jumps, bends and stretches, starts and stops, etc. are performed. In this context, injuries are more frequent among amateur players than among professionals, especially due to the false concept that claims you do not have to be in shape to play paddle tennis. In fact, the number of injuries increases significantly with age and body mass index[8-9].

Two joints are particularly affected in paddle tennis: the knees and elbows. This is why the locomotor system is where the highest concentration of frequent injuries is found (epicondylitis or tennis elbow, ankle sprains, etc.) Chard *et al.*[10] regarding 631 injuries - excluding paddle tennis players - observed that traumatic injuries were most frequent in squash (59%), compared to tennis (21%) or badminton (20%).

With regards to vascular disease, and following the example of other racket sports, its frequency should be sporadic. However, this can change given the high and growing number of paddle tennis players. Precisely, the recent diagnosis and treatment of axillary subclavian thrombosis (Paget-Schroetter Syndrome) in an amateur paddle tennis player, motivated this study.

Material and method

SA search was performed on PubMed/Medline up to 1st August 2019 using the following terms: "Padel", "Padel players" or "Padel sport"; 5 references were found, despite none of them being related to vascular disease.

We widened the search using the following terms: "Paddle", "Paddle Tennis", "Tennis", "Tennis player", "Racket", "Racket player", "Racket sport", "Racquet player", "Racquet sport", "Athlete", and "Sport", both individually as well as combined with the following terms: "Vascular diseases", "Vascular disorders", "Vascular injuries", "Arterial diseases", "Arterial disorders", "Arterial injuries", Venous disease", "Venous disorders", "Venous injuries", "Venous thrombosis", and "Venous thromboembolism".

Another search was performed collectively, using similar key words, in four Spanish journals: Angiología (channel of communication of the Spanish Angiology and Vascular Surgery Society), Medicina del Deporte Archives (official publication of the Spanish Federation and Society of Sports Medicine), Apunts. Medicina de l'Esport (Consell Català de l'Esport), and Revista Andaluza de Medicina del Deporte (Official publication of the Andalusian Sports Medicine Centre.

Vascular injuries and paddle tennis

We did not find any specific references of paddle tennis (or paddle) and vascular injuries. To focus on the issue of vascular injuries we used the bibliography available about racket/stick sports in general and tennis in particular.

Table 1 displays the different pathologies and vascular injuries linked to playing a racket sport. In this respect, at least five arterial and four venous diseases have been linked to the practice of tennis[11-14] and these may logically appear in paddle tennis.

Table 2 displays the different pathologies and vascular injuries linked to some racket sports that have been reported in medical literature[4,15-33]. Evidently, only 15 clinical cases and 5 reviews have been described.

Table 1. Vascular diseases described in racket sports[11-14].

Arterial disease
Ischaemia in the upper extremities:
- Upper thoracic outlet syndrome
- Entrapment of the humeral artery
- Raynaud Syndrome *
- Hypothenar hammer syndrome *
Ischaemia in the lower extremities:
- Entrapment of the popliteal artery
Compartment exertion syndromes (chronic)
Dissections:
- Axillary artery
Venous pathology
Deep vein thrombosis (DVT):
- Upper extremity (Paget-Schroetter Syndrome)
- Lower extremity
Varicose veins
Venous traumatises:
- Venous tears (Tennis leg syndrome) **

* Pathology with similar components.
** Tennis leg: Differential diagnosis with the DVT.

Table 2. Vascular pathology in the practice of racket/stick sports. Literary review.

Author/s (country) [reference]	Review, year	Sport	Pathology	Type publication
Coon & Willis (USA)[15]	Arch Surg, 1967	Tennis	Axillary subclavian DVT. Paget-Schroetter Syndrome	C
Brunner (Germany)[16]	Z Unfallmed Berufskr, 1968	Badminton	Axillary subclavian DVT "exertion-induced". Paget-Schroetter Syndrome	C
Languasco, *et al* (Italia)[17]	Angiologia, 1988	Tennis	Copo di fusta or Tennis leg	R
Priest (USA)[18]	Clin Sports Med, 1988	Tennis	Thoracic outlet syndrome (TOS)	R
Gilbert & Ansari (USA)[19]	Hosp Pract (Off Ed), 1991	Tennis	Calf swelling	C
Capek & Holcroft (USA)[20]	J Vasc Interv Radiol, 1993	Tennis	Traumatic ischaemia in the hand	C
Koga, *et al* (Japan)[21]	Am J Sport Med, 1993	Badminton	Hypothenar hammer syndrome	C
Stubington & Rigg (GB)[22]	Br J Sport Med, 1995	Squash	Arterial-venous fistula Traumatic superficial temporal artery	C
Nakamura, *et al* (Japan)[23]	Eur J Vasc Endovasc Surg, 1996	Tennis	Hypothenar hammer syndrome	C
Weber & Churchill (Australia)[24]	Aust NZ J Surg, 1996	Squash	Chronic compartment syndrome (leg)	C
Caiati, *et al* (USA)[25]	Am J Sport Med, 2000	Tennis	Dissecting of the axillary artery	C
Noel & Hayoz (Switzerland)[26]	Vasa, 2000	Tennis	Claudication of the hand (hypothenar hammer syndrome)	C
Zell, *et al* (Germany)[27]	Angiology, 2001	Racket	Paget-Schroetter Syndrome	R
Pluim, *et al* (Netherlands)[5]	Br J Sport Med, 2006	Tennis	Diverse	R
Vasdekis, *et al* (Greece)[28]	J Vasc Surg, 2006	Tennis	Closed trauma of the common femoral artery	C
Kohen, *et al* (USA)[29]	Del Med J, 2013	Lacrosse	Axillary subclavian DVT: Paget-Schroetter Syndrome	C
Ise, *et al* (Japan)[30]	J Cardiol Cases, 2014	Tennis	PTS popliteal (traumatic)	C
Tracy, *et al* (USA)[31]	Curr Sport Med Res, 2016	Lacrosse	Arterial-venous fistula Traumatic superficial temporal artery	C
Abe & Fujii (Japan)[32]	J Hand Surg Asia Pac Vol, 2017	Tennis	Chronic compartment syndrome (forearm)	C
Bhatia, *et al* (India)[33]	Med J Armed Forces India, 2019	Tennis	Tennis leg	R
Lozano (Spain)	Arch Med Deporte, 2019	Paddle tennis	Axillary subclavian DVT: Paget-Schroetter Syndrome	C

USA, United States of America; GB, Great Britain.
* C: Clinical case: R: Review

The exceptionalness of vascular injuries caused by playing a racket sport, is not an excuse for its infra-diagnosis, particularly in sports such as paddle tennis, which is practised by a large part of the general public, who even without playing this sport would suffer its epidemiological impact (by age groups, sex and the presence of other risk factors) on vascular diseases, fundamentally those with a high incidence rate and prevalence (e.g. intermittent claudication, venous thrombosis or varicose veins).

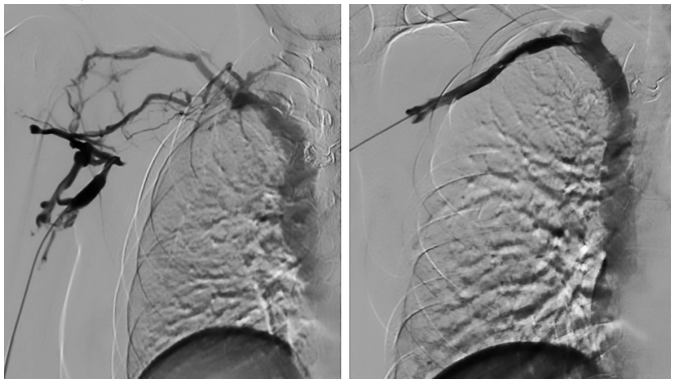
Paget-Schroetter Syndrome

A clinical case is presented, which according to our review is the first described in medical literature in connection with paddle tennis. A collective update is performed (literary review).

Clinical case

34-year old male, with no personal or family antecedents of interest, no toxic habits, no known allergies; claims to have played paddle tennis regularly (2-3 sessions/week, for the past 5 years). He came to A&E with pain and swelling in his right arm that appeared suddenly 5 days before, following one of his regular paddle tennis matches. A D-dimer test (elevated) was requested, as well as an Echo-Doppler, confirming an axillary subclavian venous thrombosis in the upper right extremity (his dominant arm). A diagnostic probability test was not performed. Given that he did not have any antecedents of interest, except for the exertion mentioned, the patient was diagnosed with Paget-Schroetter Syndrome. The patient was admitted into hospital and administered sodium heparin IV in therapeutic measures. The following morning, the patient was sent to a clinical session; given his age, recent clinical history and low risk of bleeding, the collective opinion was to propose fibrinolytics treatment. After informing the patient (risks and benefits), he accepted to undergo fibrinolytics. Local urokinase was administered intra-thrombus via catheter. The patient was admitted into the intensive

Figure 1. Phlebography and local fibrinolytics via catheter: Pre-fibrinolytics (axillary subclavian venous thrombosis) and post-fibrinolytics (resolution of the thrombus).



monitoring unit for analytical monitoring (coagulation, fibrinogen, etc.); in the second angiographic control at 24 hours, re-permeability was observed (Figure 1). The patient was moved to the ward, continuing with anticoagulation (sodium heparin IV). On the 6th day of admission, he was released with oral anticoagulation. During his hospital stay, a thoracic Angio-RM was performed, revealing no osteo-articular alteration of the thoracic outlet. The thrombophilic study was normal. The patient was sent to the thoracic surgery department, where his first rib was successfully resected via video-thoracoscopy. Currently, two months after release from hospital, the patient has no symptoms, and is continuing with the oral anticoagulant treatment (rivaroxaban 20mg/day). He has been advised to refrain from playing paddle tennis until further medical examinations.

Discussion

Deep vein thrombosis (DVT) is a frequent illness, linked to serious complications (e.g. pulmonary embolism - PE) and aftereffects (e.g. post-thrombotic syndrome - PTS) that entail important clinical, social and economic repercussions. Its basic etiopathogeny was described over a century ago (Virchow, 1860). Along this line of ideas, there are numerous illnesses and syndromes associated to DVT. Among them we highlight Paget-Schroetter Syndrome, which in our opinion presents three important characteristics: 1) Infrequent; 2) Fundamentally affects young people (< 40 years), often athletes; and 3) Is relatively unknown by non-specialists in venous pathology; this can lead to errors (diagnostic and therapeutic) with possible consequences, which can occasionally be serious (fatal PE).

Based on our experience[34] and a literary review[35-46], we present the most relevant aspects of this syndrome (concept, frequency, etiopathogeny, clinical history, diagnosis and treatment), with the aim of facilitating early diagnosis, optimising treatment and thus improving the prognostic (mortality rate) of this entity.

Concept and classifications: Initially it is necessary to define thoracic outlet syndrome (TOS). The outlet/inlet of the most important neurovascular structures of the thorax to the arm or vice versa, should cross three anatomical areas that can be conflictive: 1) Interscalene triangle (intercostal-scalene space); 2) Costo-clavicular channel; and 3) Coracopectoral tunnel (sub-pectoral/subcoracoidal area). There are a whole host of causes (cervical rib, subclavian muscle hypertrophy, etc.) and syndromes (scalene syndrome, pectoralis major syndrome, etc.) that may compress some or all the existing neurovascular structures (brachial plexus, artery and subclavian vein) (Figure 2). However, the impact is spread differently: neurological (95%), arterial (4%) and venous (1%).

In turn, venous TOS can be classified as: 1) Compression without DVT (denominated McCleery syndrome and characterised with venous swelling), and 2) Compression with DVT: this latter group, depending on aetiology, is subdivided into: a) Primary (25%) or Paget-Schroetter Syndrome (spontaneous or strain-induced axillary subclavian thrombosis) and b) Secondary (75%). Secondary aetiology is linked fundamentally to central venous channelling techniques (diagnostic or therapeutic - reservoirs), but they can also be due to polyglobulia, congestive cardiac insufficiency or extrinsic compressions for different pathologies (e.g. primary or metastatic cancer)[35].

Figure 2. Anatomy of the thoracic outlet. Conflictive zones of possible venous compression.

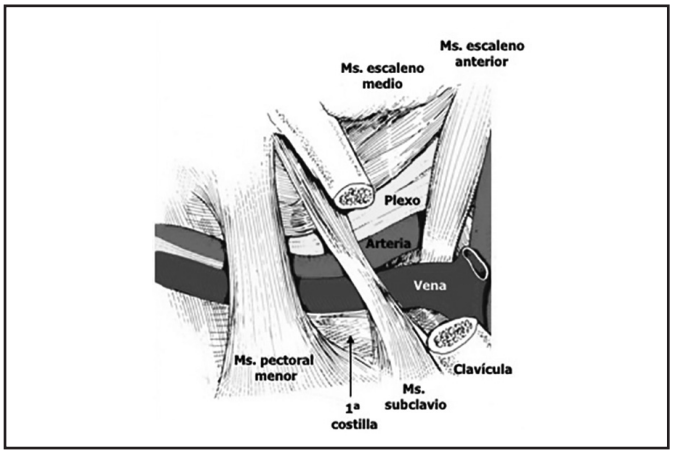
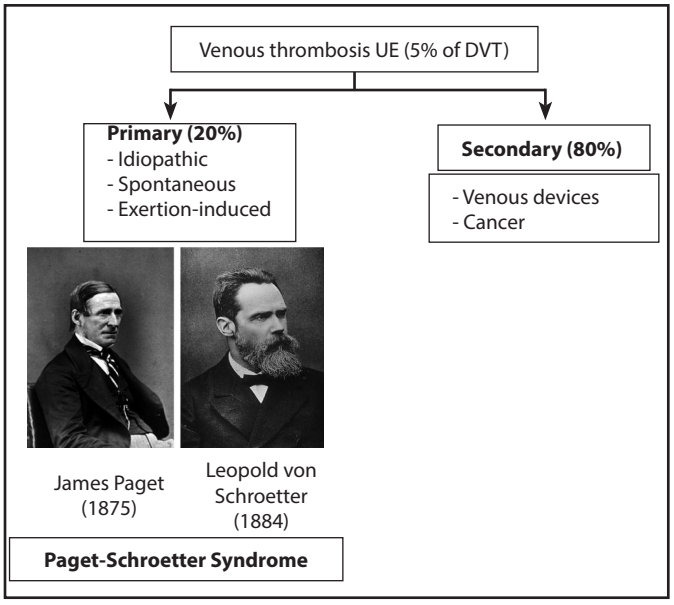


Figure 3. Classification of the venous thromboses in the upper extremity.



Historical overview: the English pathologist, James Paget (1875)[36] and the Austrian internist, Leopold Schrötter Ritter von Kristelli (known in medical literature as Leopold von Schrötter) (1884)[37], independently studied and characterised the syndrome. In 1949, Hughes performed a literature review and discovered 320 cases, proposing the term "Paget-Schroetter Syndrome"[38] (Figure 3).

Frequency: if the DVT of the upper extremities represent around 5% of al DVT cases, Paget-Schroetter Syndrome represents 1% of all venous thromboses. Over the past 5 years, in our department, 3 or 4 cases/year have been diagnosed/treated; two of them related to playing basketball.

Etiopathogeny: although the aetiology of the syndrome is unknown, it is usually related to two factors: a) repeated venous trauma, of diverse intensity and b) anatomical alterations that produce compressions. Strain is present in around 70% of cases. In fact, a third of the cases are people that play physically exerting sports, i.e. those in which the athletes repeatedly use their upper extremities (Table 1)[11-14], and interestingly, it has even been seen in a cheerleader36. Another third appears in professionals that also use their arms repeatedly. The remaining third appears in sedentary patients.

Along with the triggering situation (exertion-induced), there are other predisposing factors: anatomical defects (thoracic outlet syndrome), anovulatory defects, or unknown thrombophilic states. Anatomic defects are present in 90% of the cases, and are bilateral in 65%. This anatomical defect (muscular, bone, etc.) induces the compression of some (or all) vascular-nervous structures (in our case, the axillary and/or subclavian vein) that leave/enter the thorax, fundamentally during forced positions upon performing the exertion, which if repeated, causes the thrombosis of said vein. However, there may be anatomic defects without venous thrombosis and vice versa[35,40-42].

Production mechanism: accordingly, an axillary-subclavian DVT, generally in the dominant arm of a paddle tennis player, would be explained through a combination of factors: a) Triggers (repeated shoulder movements, linked to exertion positions - arm abduction) (Figure 4). Predisposition (vein compression by abnormal anatomic structures), not forgetting a hidden thrombophilic alteration or the ingestion of anovulatories (women of fertile age comprise a quarter of all paddle tennis players), which should also be researched.

Clinical: more frequent among males (2:1) and young people (average age of appearance: 31 years of age, range between 23-53). The dominant extremity is affected in 70% of the cases, with bilateral cases representing 7%[35,40-42].

The most symptomatic patients presented suddenly-appearing swelling (80%) and pain (30-50%) in the arm. Upon physical examination, there was frequently bruising, alteration of the colour of the skin and collateral circulation (Urschel sign) in the most developed cases[35,40-42].

Diagnosis: just as with the lower extremities (LE) (Wells test) for the upper extremities (UE), there is also a diagnostic probability test for DVT (Constans *et al,* 2008)[43]. This comprises four items: the presence of a catheter inserted in the vein (1 point), localised pain (1 point), unilateral swelling (1 points), and alternative diagnosis (- 1 point). A score below 1 point indicates the unlikelihood of DVT (which is ruled out when associated with a negative D-Dimer); more than 1 point implies that DVT is likely and requires the use of image techniques to confirm/reject the DVT diagnosis.

The D-dimer is less useful in terms of DVT and LE. The Echo-Doppler (97% sensitivity and 96% specificity), is the test of choice. MRA or angio-CTA (resting and hyper-abduction manoeuvres - Wright) are highly useful diagnostic tools. As phlebography (resting and manoeuvres) is an invasive technique, is relegated as a secondary diagnosis option[35,40-42].

Treatment: although initial standard treatment is anticoagulation (3 months), direct fibrinolytics via catheter is indicated for thromboses with less than 14 days of development, in young patients, and those with low risk of haemorrhaging. Later, in selected cases, a surgical technique can be performed of decompressing the sub-clavicle vein4; however, this is a controversial issue that is not part of the objective of this review. The filter of the superior vena cava may be indicated in situations in which anticoagulation is contraindicated[44].

The treatment purpose should be two-fold: a) Preventing the risk of PE, and b) Preventing PTS. Various actions have been trialled: 1) Regarding the thrombus: anticoagulant (not very effective); thrombectomy (classic or percutaneous); systemic or local fibrinolytics. The latter options appear to be the most useful, but for maximum effectiveness it is essen-

Figure 4. Pathogens of the Paget-Schroetter Syndrome. Abduction position of the arm whilst playing paddle tennis.

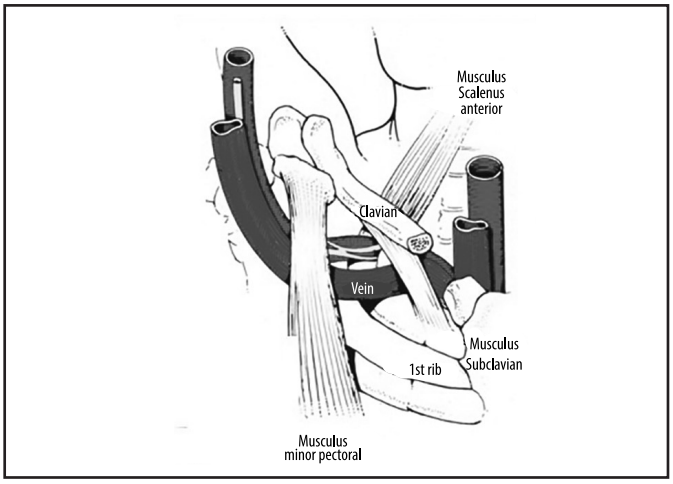
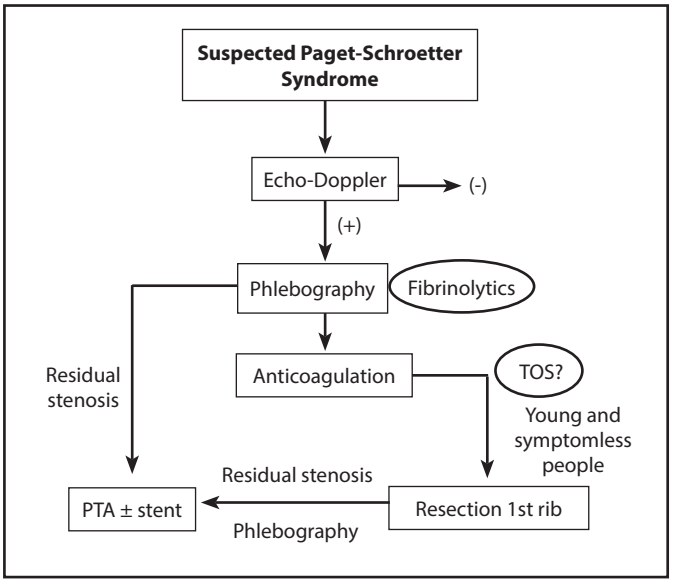


Figure 5. Therapeutic algorithm of Paget-Schroetter Syndrome (TOS, thoracic outlet syndrome; PTA, percutaneous transluminal angioplasty).



tial for the thrombus to be around 7 days old (Figure 1); 2) Regarding compression (diverse techniques, e.g. Resection of the first rib); and 3) Regarding residual stenosis: Percutaneous transluminal angioplasty (PTA) with/without stent. This therapeutic action is usually gradual. Figure 5 displays a simplification of the algorithm we use in our service.

As a treatment appendix, there are publications that make specific recommendations for the anticoagulant treatment of DVT in athletes[45,46].

Development: PE appears in 5-9% of cases (30% in DVT that affects the LE). PTS appears in 20% (40-50% in LE). Venous rethrombosis is also lower compared to LE DVT[35, 40-42].

Prognosis: early and correct diagnostic-therapeutic handling of the syndrome proffers excellent results and allows for a return to sporting activity, as observed in professional players from some of the four major American leagues (baseball, basketball, American football and ice hockey)[3]. During the anticoagulant (and antiaggregate) treatment, practising sport is completely contraindicated. Despite paddle tennis not being a contact sport, is does entail the risk of falls and trauma (e.g. "Tennis leg"). In any case, the recovery period may extend to 3-6 months.

Conclusion

Basic recommendations: 1) Think about this entity, especially for young, active and healthy patients; 2) Treat the thrombosis with anticoagulation and in select situations with fibrinolytics; and 3) Aim, and on select cases, to treat the anatomic cause.

Adendum

After this drafting of this study, the Angiology and Vascular Surgery Department of the University of Salamanca Healthcare Complex treated a 54-year old male patient who was a regular paddle tennis player and doctor, who had come from Avila with a provisional diagnosis of hamstring-tear syndrome or deep vein thrombosis (DVT). In our department we performed an Echo-Doppler and confirmed thrombosis in the muscular veins (calf muscles) of the lower right extremity, without progression to the popliteal vein, and without signs of bruising or muscle tearing. Anticoagulation was recommended with low molecular weight heparin (LMWH) (1-3 months) and elastic compression stockings. Given his position as a doctor, he opted to continue follow-up in his home city.

Comments: 1) Remember that the muscular veins (calves and soleus) belong to the deep vein system of the lower extremities; 2) In these situations it is very important to differentiate between a fibre tear (tennis leg) and DVT (though it may be distal and confined to the calf); however, occasionally both entities may be present; 3) Only an exact diagnosis facilitates correct decision making, so whilst in the first case (fibrillar tear) the administration of LMWH would possibly increase the symptoms (more bleeding), in the DVT - despite being distal and isolated - LMWH may be recommendable, especially when the thrombus is extensive (> 5 cm in length) and when it affects more than one muscle vein, such as in this case. If in doubt, the clinical development of the patient can be observed and serial Echo-Doppler sessions (weekly) can be carried out. Anticoagulation can be chosen only if the thrombus progresses to the popliteal vein; however, distal and isolated DVT can - infrequently - also cause pulmonary embolisms[46-47].

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Conflict of interest

The authors claim to have no conflict of interest whatsoever.

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