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ORIGINAL ARTICLE

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Association between vascular injury identified via echo-Doppler examination and talus fracture-dislocation

Associação entre lesão vascular pelo exame de eco-doppler e fratura-luxação do tálus

Andresa Ramires Hoshino Ferreira[1], Rui dos Santos Barroco[1], Álvaro Diego Pupa de Freitas[1], Bruno Rodrigues de Miranda[1], Letícia Zaccaria Prates de Oliveira[1], Mahmoud Beerens Abdul Ghani[1]

1. Faculdade de Medicina do ABC, Santo André, SP, Brazil.

ABSTRACT

Objective: To investigate the association between talus fracture-dislocation and the occurrence of pre-operative vascular injuries identified via echo-colour Doppler examination of the lower limbs and to assess whether these injuries directly affect talar necrosis.

Methods: Retrospective study with data collection on 26 patients with a diagnosis of talus fracture-dislocation who were evaluated by pre-operative arterial and venous echo-colour Doppler from 2004 to 2015.

Results: The sample included 26 patients (26 feet), ranging in age from 16 to 62 years, with a mean follow-up time of 2 years and 9 months. A total of six (23.07%) changes were diagnosed via echo-colour Doppler, of which five (83.33%) were due to arterial injury of the 'segmental occlusion of the posterior tibial artery' type and one (16.67%) was due to venous injury of the 'recent deep venous thrombosis of the popliteal-distal segment' type, with no arterial injury. No significant association was found between the vascular injuries diagnosed by Doppler and progression to necrosis.

Conclusion: A significant portion of the patients with talus fracture-dislocation presented with vascular injury diagnosed by echo-colour Doppler, although no association was found between vascular injury and outcomes of osteonecrosis.

Level of Evidence IV; Prognostic Studies; Case Series.

Keywords: Fractures, bone; Talus; Vascular system injuries; Necrosis.

RESUMO

Objetivo: Investigar a associação entre fratura-luxação do tálus a e ocorrência de lesões vasculares pré-operatórias identificadas pelo exame de eco-color-doppler dos membros inferiores e avaliar se essas lesões interferem diretamente com a necrose do tálus.

Métodos: Trabalho retrospectivo, de levantamento de dados em que foram avaliados 26 pacientes, entre 2004 a 2015, que possuíam o diagnóstico de fratura-luxação do tálus e haviam sido avaliados pelo eco-color-doppler arterial e venoso pré-operatório.

Resultados: Amostra de 26 pacientes (26 pés), com idade variando entre 16 a 62 anos com tempo de seguimento médio de 2 anos e 9 meses. Foram diagnosticados um total de seis (23,07%) alterações no eco-color-doppler, sendo cinco (83,33%) alterações por lesão arterial do tipo oclusão segmentar da artéria tibial posterior e uma (16,67%) lesão venosa do tipo trombose venosa profunda recente do segmento poplíteo-distal, sem lesão arterial. Não foi encontrada uma associação estatística significativa entre as lesões vasculares diagnosticadas pelo doppler e a evolução para necrose.

Conclusão: Uma parcela significativa dos pacientes com fratura-luxação do tálus apresentou lesão vascular diagnosticada pelo eco-color-doppler, embora não tenha sido comprovada a associação entre as lesões e o desfecho para osteonecrose.

Nível de Evidência IV; Estudos Prognósticos; Série de Casos.

Descritores: Fratura; Tálus; Lesões do sistema vascular; Necrose.

Work performed at the Hospital Estadual Mário Covas, Santo André, SP, Brazil.

Correspondence: Rui dos Santos Barroco. Rua Afonso Brás, 817 – Vila Nova Conceição. CEP: 04511-011 – São Paulo, SP, Brazil.
E-mail: ruibarroco@uol.com.br

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INTRODUCTION

The talus is the central component in the biomechanics of the ankle-hindfoot-midfoot complex. Circulation in the talus is achieved by vessels that enter it through five sites: the talar neck, the medial and lateral surfaces of the talar body, the tarsal canal, and above the posterior talar process. These vessels are fed by the posterior tibial and dorsalis pedis arteries, in addition to the lateral malleolar network, which consists of the anastomosis of the fibular and dorsalis pedis arteries. The extraosseous and intraosseous arterial pathways are subject to variations already described in the literature[1].

Due to its unusual vascular supply, talus fractures may develop serious complications due to damage to the blood supply. The impairment of local microcirculation may lead to talar osteonecrosis and result in severe functional impairment during patient follow-up. Although it is recognized that damage to circulation is related to poor clinical outcomes, reports of pre-operative, post-traumatic arterial injuries are uncommon in the literature, and the influence of these injuries on natural fracture evolution is unknown.

The literature describes injuries of the posterior tibial artery arising from closed ankle injuries or post-operative complications of trauma[2]. In 2010, Barroco et al.[3] reported two cases of association of posterior tibial artery injury with Hawkins type III fracture-dislocation, but there was no effects of this injury on the patients' short-term progression[3].

Considering the lack of reports on the association between vascular injuries and talus fracture-dislocation, the aim of this study was to investigate the frequency of vascular injuries identified via Doppler echocardiography of the lower limbs in the pre-operative period and to evaluate whether these injuries directly affect talar necrosis.

METHODS

This study was approved by the Ethics Committee with registration in the Brazil Platform under CAAE number 78699417.1.0000.0082.

This is a retrospective study with data collected from the medical records of patients seen at the outpatient clinic of the Foot and Ankle Surgery group in a tertiary hospital between 2004 and 2015. Patients with a diagnosis of talus fracture-dislocation who had been evaluated by arterial and venous echo-colour Doppler of the affected lower limb as part of the pre-operative routine by the same examiner, staff member and radiology group preceptor were included. The following structures were evaluated with the echo-colour Doppler examination: common femoral artery, deep femoral artery, superficial femoral artery, popliteal artery, posterior tibial artery, anterior tibial artery, fibular artery, common femoral vein, deep femoral vein, superficial femoral vein, popliteal vein, posterior tibial veins, anterior tibial veins, fibular veins, and gastrocnemius veins.

A total of 29 skeletally mature patients (29 feet) with talus fracture-dislocation were identified, and three patients without an echo-colour Doppler were excluded. Therefore, 26 patients (26 feet) were included, of whom 76.92% were male and 23.08% were female, ranging in age from 16 to 62 years old (mean age, 36 years). The sample included 21 consecutive cases of talus fracture-dislocation and five cases of peritalar dislocation, twelve in the left foot and fourteen in the right foot.

Patients underwent the same protocol in the post-operative period and were evaluated using periodic simple radiographs taken in anterior and lateral views. Follow-up ranged from 7 months to 8 years, with a mean follow-up time of 37.38 months. During follow-up, all patients with radiographic suspicion of talar osteonecrosis underwent a confirmatory magnetic resonance imaging examination at one year of progression. No patient was excluded from the study because of loss of follow-up.

To describe the types of talus fractures, the most currently accepted classification was described by Hawkins[4] in 1970 and later modified by Canale and Kelly[5] in 1990. However, in this classification, the degree of necrosis was not correlated with the vascular injury.

The exclusion criterion was not having undergone echo-colour Doppler examination as part of the pre-operative routine, n=3. We previously defined other exclusion criteria, such as associated fractures of the lower limbs, open lesions in which it was not possible to exclude a vascular injury due to external cutting or blunt injury, and vasculopathy prior to the traumatic injury, but no patients were excluded using these criteria.

Ultrasound images obtained using a Siemens Acuson X-300 with a CH5-2 convex probe (2-5 MHz) and VF8-3 (3-10 MHz) / VF10-5 (5-10 MHz) / VF13-5 (5-13 MHz) linear probe combined with high-frequency sound wave analysis were used to examine the haemodynamic behaviour of arterial and venous injuries by calculating the speed and pattern of the spectral curve in the various segments evaluated[6].

The frequency of vascular injury was analysed according to side and sex. Additionally, the groups with and without vascular injury were compared in regard to the presence or absence of osteonecrosis, without specifically considering the affected area. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 23.0. Fisher's exact test was applied, and the relative risk of having necrosis in the presence of vascular injury was calculated.

RESULTS

The data on laterality, sex, age, and follow-up time are shown in Table 1. In our study, the follow-up time of these patients ranged from 7 months to 8 years, with a mean follow-up time of 37.38 months.

A total of six (23.07%) changes were diagnosed by echo-colour Doppler examination (Figure 1), five (83.33%) of which were arterial injuries of the 'segmental occlusion of the posterior tibial artery with plantar artery filling' type and one (16.67%) venous injury of the 'recent deep venous

Table 1. Description of the evaluated cases

Case	Age	Sex	Side	Classification	Doppler	Lesion	Necrosis	Time (months)
1	16	F	Right	Hawkins III	No injury			12
2	17	F	Right	Hawkins III	No injury			9
3	17	M	Right	Hawkins III	No injury		Present	12
4	23	F	Left	Hawkins III	No injury			8
5	25	F	Right	Hawkins III	No injury			7
6	25	M	Left	Hawkins III	No injury			36
7	25	M	Left	Hawkins III	No injury			60
8	26	M	Right	Hawkins III	No injury		Present	24
9	28	M	Left	Hawkins III	With injury	Arterial	Present	36
10	29	M	Left	Hawkins III	With injury	Arterial		12
11	30	M	Left	Hawkins III	No injury			72
12	32	M	Right	Hawkins III	No injury		Present	36
13	34	M	Left	Hawkins III	No injury	Arterial		24
14	35	M	Left	Hawkins III	No injury			60
15	39	M	Right	Hawkins IV	No injury	Arterial	Present	96
16	40	M	Right	Hawkins III	With injury	Arterial		72
17	40	M	Left	Hawkins III	No injury			36
18	42	M	Right	Hawkins IV	No injury		Present	12
19	46	M	Left	Hawkins III	No injury			24
20	47	F	Right	Hawkins III	No injury			24
21	47	M	Right	Hawkins III	No injury		Present	48
22	51	M	Right	Hawkins III	No injury		Present	72
23	52	M	Left	Hawkins IV	No injury		Present	48
24	53	M	Right	Hawkins IV	With injury	Venous		36
25	55	M	Right	Hawkins III	No injury			36
26	62	F	Left	Hawkins III	No injury			60
TOTAL		76.92%	53.85%		23.07%	83.33%	34.61%	
		Male	Right		With injury	Arterial	With necrosis	
		23.08%	46.15%	84.62% tipo III	76.93%	16.67%	65.39%	
		Female	Left	15.38 % tipo IV	With injury	Venous	without necrosis	
Mean	36							37.38
Mode	25							36
Median	34,5							36

Source: Prepared by the author based on the results of the study.

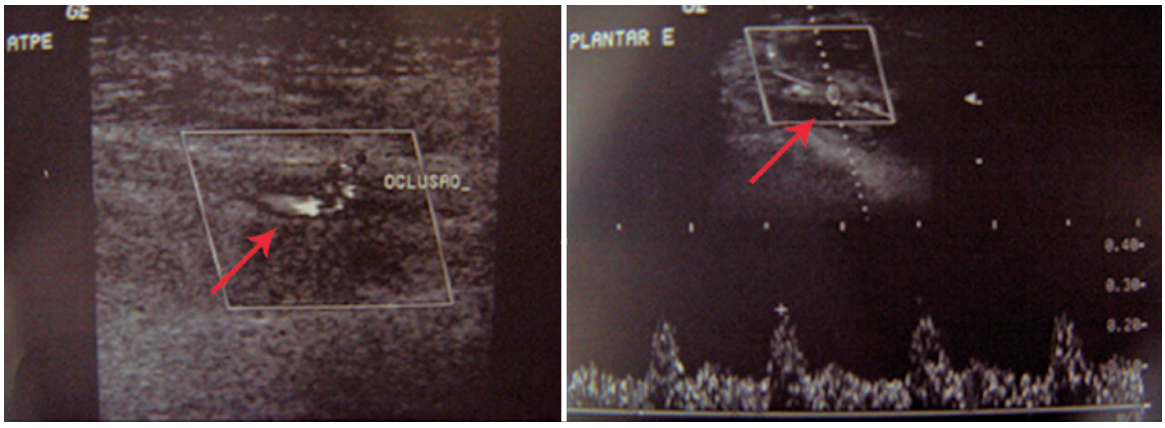

Figure 1. Ultrasound image showing arterial occlusion.
Source: Author's personal archive.

thrombosis of the popliteal-distal segment' type, without arterial injury (Table 1).

Of the six injuries found via echo-colour Doppler examination, four were classified as Hawkins type III and two as type IV, indicating that the relationship between the injuries diagnosed in the pre-operative period by echo-colour Doppler examination was not significant when compared to progression to necrosis; that is, there was a similarity between the categories with injury and without injury on examination when progression to necrosis was observed (Table 2).

The relative risk of having necrosis in the presence of injury was 0.929 (95% confidence interval 0.135-6.398).

Table 2. Statistical analysis

Doppler	Statistic	Necrosis		Total
		With	Without	
With injury	Frequency	2	4	6
	Percentage	33.30%	66.70%	100.00%
Without injury	Frequency	7	13	20
	Percentage	35.00%	65.00%	100.00%
Total	Frequency	9	17	26
	Percentage	34.60%	65.40%	100.00%

Source: Prepared by the author based on the results of the study.

DISCUSSION

The vascularization of the talus depends on some major arterial branches. Branches of the posterior tibial artery reach the medial portion of the posterior talar process. The lateral malleolar network, originating from the fibular artery, supplies the lateral portion of the posterior process. The medial third is supplied by the branches of the deltoid artery and the anterior tibial artery, whose branches also supply the talar neck[7,8]. Considering this anatomical reference, the posterior, anterior, and fibular arteries, as the main branches of the arterial supply of the talus, were used in the ultrasound evaluation in the present study, in addition to the inferior drainage system of the lower limb.

The importance of Doppler ultrasound for vascular assessment of the lower limbs is emphasized by many studies. According to the guidelines of the Brazilian Society of Cardiology, Doppler is currently the most versatile diagnostic tool to evaluate peripheral artery diseases due to its non-invasive character and sensitivity and specificity of more than 90% for the iliofemoral segment and the popliteal artery and vein region. Panetta et al., in an experimental study, reported that echo-colour Doppler examination and arteriography showed equivalent accuracy rates in the diagnosis of arterial lesions, with echo-colour Doppler being significantly more sensitive and accurate for identifying arterial lacerations[9].

In regard to the trauma mechanism that generates the talar fracture and leads to a possible vascular injury, the talar body is more frequently diverted posteriorly and medially, rotating on its horizontal and transverse axis, but neurovascular structures generally remain intact since they lie anterior to the flexor hallucis longus tendon, which protects them[10]. Vascular injury could then be caused by a variation in the usual talar deviation or by a higher energy trauma that could lead to additional soft tissue injuries.

It should be noted that talus fractures are usually caused by high-energy trauma. In 2001, Heckman et al.[11] concluded that the incidence of cases of talar and/or peritalar fracture dislocation affected young men more frequently[10]. This finding is consistent with our sample and is a reality observed in all fractures involving high energy trauma since, in general, men are more exposed to this type of event.

Among the non-bone injuries associated with traumatic injuries of the foot and ankle, there are reports of rupture of the posterior tibial tendon[12]; injury of the Achilles tendon[13], anterior talofibular ligament and peroneus longus tendon[14]; aneurysm[15]; and thrombosis[16] of the posterior tibial artery, but without extensive documentation of the frequency of arterial injuries or their repercussions in the outcome of the cases.

Avascular necrosis and arthrosis are common in talar fractures due to neurovascular injury[17]. The collapse of the talar dome can occur due to degenerative changes and the loss of talar bone support. Some researchers, however, have noted that avascular necrosis with segmental collapse does not necessarily exclude satisfactory results and that the presence of necrosis does not necessarily sentence the patient to arthrosis[4].

In the clinical evaluation of vascular status, which should be investigated in all cases of lower limb trauma, a diagnosis of posterior tibial artery injury cannot be confirmed with physical examination alone; in the presence of clinical suspicion, it requires complementary tests or direct exploration for diagnostic confirmation. Such diagnostic difficulty is explained by the swelling, pain, and deformity resulting from foot and ankle trauma, which make it difficult to obtain adequate and reliable clinical data[14,18].

In talus fracture-dislocations, surgical treatment must occur immediately. The suspicion of posterior tibial artery injury does not alter the fact that the patient should undergo emergency surgery, and in practice, we observed the maintenance of foot perfusion, probably at the expense of the anterior tibial arteries and/or fibular artery. However, the post-traumatic and pre-operative documentation of these injuries may facilitate the study of the pathology, in addition to indicating to the surgeon that a possible post-operative vascular change was not due to the surgical intervention.

In our study, we found a total of 23.08% of patients with vascular injury, including segmental occlusion of the posterior tibial artery with unaltered plantar artery filling in five patients (83.33%) and recent deep venous thrombosis in the popliteal-distal segment in one patient (16.67%).

Although there are no studies directly relating posterior tibial artery injury to talus fracture-dislocation, there are reports of injuries to the leg arteries associated with leg fractures[19]. These studies show, although with low levels of evidence, the possibility of good arterial flow even with the injury of an artery, for example, the posterior tibial artery.

Segal and Brenner concluded that adequate arterial flow of the foot and ankle can be maintained only in the presence of a functioning and patent artery[10]. Perhaps in the case report of Brzakala et al., which describes foot amputation after injury of the posterior tibial artery in closed trauma, there may have been an alteration in the arterial flow of the other arteries that feed the foot, explaining the evolution of the case[16].

The literature, therefore, is scarce in studies that identify the frequency of vascular injury associated with talus fracture, although the prognosis of this injury is closely related to the injury of the blood supply that the trauma causes. We suggest that further studies with a larger number of patients and a longer follow-up period may define this association and help to better understand the prognosis of this finding.

CONCLUSION

We found a high frequency of vascular injuries diagnosed by echo-colour Doppler examination in patients with talus fracture-dislocation, and it was not possible to show a relationship between this finding and the progression of this bone to necrosis.

Authors' Contributions: Each author contributed individually and significantly to the development of this article: ARHF *(http://orcid.org/0000-0001-8363-0806) conceived and planned the activities that led to the study, performed surgeries, interpreted the study results, wrote the article, participated in the review process and approved the final version; RSB *(http://orcid.org/0000-0002-2870-2261) conceived and planned the activities that led to the study, performed surgeries, participated in the review process and approved the final version; ADPF *(http://orcid.org/0000-0001-5808-1788) wrote the article and interpreted the study results; BRM *(http://orcid.org/0000-0002-5306-2972) wrote the article, participated in the review process and approved the final version; LZPO *(ttp://orcid.org/0000-0001-5849-5841) performed surgeries and interpreted the results of the study; MBAG *(http://orcid.org/0000-0003-0007-5574) performed surgeries and interpreted the results of the study. *ORCID (Open Researcher and Contributor ID).

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