Vascular trauma in the Amazon: updating the challenge.

Trauma vascular na Amazônia: atualizando o desafio.

Adenauer Marinho de Oliveira Góes Junior, TCBC-PA[1,2]; Joaquim Fernando Albuquerque Simões Neto[2]; Simone de Campos Vieira Abib, TCBC-SP[3]; Mariseth Carvalho de-Andrade[4]; Thaiana Cerqueira Ferraz, ACBC-PA[5].

A B S T R A C T

Objective: to evaluate the epidemiological data of patients operated on due to vascular trauma at a referral hospital in Pará state, to determine the variables that increase the risk of death, and to make a comparative analysis with the results previously published by the same institution. **Methods:** an analytical retrospective study was performed through data collection from patients operated due to vascular injuries, between March 2013 and March 2017. Demographic and epidemiological data, such as the mechanism and topography of the lesion, distance between the trauma site and the hospital, and type of treatment and complications, were analyzed. Multivariate analysis and logistic regression studies were performed, to evaluate significant dependence between some variables and death occurrence. **Results:** two hundred and eighty eight patients with 430 lesions were studied; 92.7% were male, 49.7% were between 25 and 49 years old; 47.2% of all injuries were caused by firearm projectiles; 47.2% of the lesions were located in the upper limbs, 42.7% in the lower limbs, 8% in the cervical region, 3.1% in the thoracic region, and 0.7% in the abdominal region; 52.8% of the patients were hospitalized for seven days or less. Amputation was required in 6.9% of patients and there was mortality in 7.93% of the cases. **Conclusion:** distances greater than 200km were associated with prolonged hospitalization and greater probability of limb amputation. Significant correlation between death occurrence and arterial injury, vascular injury in the cervical region, and vascular injury in the thoracic region was found.

Keywords: Wounds and Injuries. Vascular System Injuries. Blood Vessels. Amputation.

INTRODUCTION

Vascular injuries are among the leading causes of death in trauma patients[1-3]. The mechanisms can be divided into penetrating, the most frequent ones according to literature, and blunt, which have a worse prognosis[2,4,5]. They are frequently associated with other visceral injuries, fractures, and neuromuscular injuries, which increases morbimortality[1,6]. Victims of vascular trauma may present death risk or limb amputation. Clinical presentation, especially in massive bleeds, can be challenging for the surgeon[2,5,7,8]. Definitive treatment depends on several factors: the injured vessel, the general state of the patient, and the availability of resources, among others[5,7]. In addition, the precocity of limb reperfusion is closely related to the functional prognosis and, therefore, the distance to the trauma center and the way the patient is transferred to it influence so much the clinical outcome[3,5,8,9].

In the Amazon region, all these factors suffer the impact of peculiar territorial issues. The geographical isolation of some localities and the shortage of hospitals which perform vascular surgery oblige the transportation of patients for long distances until reaching definitive treatment. Pará is the most populous state in the Amazon, and, despite having a big territory, larger than many European countries, it has only one reference center for highly complex traumas. Located in the metropolitan region of Belém[1,5,10], the capital of Pará state, Hospital Metropolitano de Urgência e Emergência (HMUE) has a vascular surgical team permanently on duty.

The experience of this service with 255 vascular injuries (in 173 patients operated between February 2011 and February 2013) was published in 2015[5]. Now, the present study has three objectives: to evaluate the epidemiological data of patients operated on due to vascular trauma at HMUE

1 - Hospital Metropolitano de Urgência e Emergência, Vascular Surgery/Trauma Surgery Department, Ananindeua, PA, Brazil. 2 - Centro Universitário do Estado do Pará, Faculty of Medicine, Belém, PA, Brazil. 3 - Federal University of São Paulo, Surgery Departament, Postgraduate Program in Interdisciplinary Surgical Science, São Paulo, SP, Brazil. 4 - University of Pará State, Program in Research and Experimental Surgery, Belém, PA, Brazil. 5 - Hospital Metropolitano de Urgência e Emergência, Medical Resident Program in Trauma Surgery, Ananindeua, PA, Brazil.

between March 2013 and March 2017 (trauma mechanism, injury topography, surgical technique used for treatment, clinical outcomes of the patient, distance between the trauma site and the hospital and its impact, and unfavorable outcomes), to determine the variables that increase death risk among vascular trauma victims, and to make a comparative analysis with the previously published results, referring to the casuistry from 2011 to 2013 in the same institution.

METHODS

Retrospective, analytical study of data collected from medical records of patients attended at HMUE between March 2013 and March 2017. As in the previous study, the following factors were analyzed: the trauma date, gender and age of the patient, distance between the trauma site and the hospital, mechanism and topography of the lesions, surgical technique employed, postoperative evolution, re-intervention necessity, and hospitalization period.

Inclusion criterion was: patients submitted to surgery due to arterial or venous injuries between March 2013 and March 2017. Exclusion criteria: absence of vascular lesion at surgical exploration; iatrogenic lesions; traumatic limb amputation; primary amputation; and lesions treated by specialists other than vascular surgeons.

Regarding the trauma mechanism, the injuries were classified as firearm's projectile wound (FPW), inflicted by projectiles of any type; cutting wounds (CW), inflicted by metal plates and glass; and traffic accidents (TA). Less frequent mechanisms such as falls from height, crushes, and others were grouped separately.

According to Markov *et al*.[11], arterial and venous lesions were classified as compressible vascular injuries (CVI), if hemorrhage could be interrupted by direct wound compression or by tourniquet, or as non-compressible vascular injuries (NCVI), if bleeding could not be contained by these maneuvers.

The following postoperative complications were investigated: the occurrence of hematoma or surgical wound infection requiring abscess or clot surgical drainage, debridement and/or limb amputation, occlusion and graft rupture, among others. Surgical re-interventions were considered, but only those related to vascular injury after attempted revascularization (example: fasciotomies or thrombectomies of grafts). Any secondary non-vascular procedure was excluded from this analysis (laparotomy for second-look, for example).

To determine vascular injury mortality, patients who sustained non-vascular injuries at a different topography (for example, a patient with a femoral artery lesion and a brain injury caused by firearm projectile) were excluded from this analysis.

Limb amputation, hospitalization for more than seven days and death were considered unfavorable outcomes. The distance between the site where the vascular injury occurred and the referral hospital was measured in kilometers (km) using Google Maps® (www.maps.google.com.br/maps), by tracing the road traveled. Distance ranges were classified as 50km or less, between 51 and 100 km, between 101 and 200 km, between 201 and 300 km, and more than 300km.

The non-parametric chi-squared test (χ^2 test) was used and statistical significance was considered when $p<0.05$. In the multivariate analysis, first the correlation matrix was calculated to define the variables that showed correlation with the dependent variable (death). After selecting the correlated variables, the logistic regression equation was developed to make it possible the calculation of probabilities in relation to each possibility of the independent variables. Patients

with associated non-vascular lesions were excluded from the analysis.

The research was approved by the Ethics Committee of Centro Universitário do Estado do Pará (CESUPA) - registration 1,471,687.

RESULTS

Between March 2013 and March 2017, 542 patients were operated by the Vascular Surgery team of HMUE. After applying inclusion and exclusion criteria, 288 patients with 430 traumatic vascular lesions were selected. There were 173 isolated arterial lesions, 33 exclusively venous lesions, and 224 simultaneous arterial and venous lesions. Among these 288 patients, 267 (92.7%) were male, while only 21 (7.3%) were female (p=0.0001). The other epidemiological characteristics (age, trauma mechanism, lesion topography, and type of injured vessel) are shown in figure 1.

The isolated arterial lesion was found in 157 patients (54.5%), whereas exclusively venous trauma occurred in 30 patients (10.4%). Simultaneous arterial and venous lesions were found in 101 cases (35.1%). Among the arterial lesions, 228 (88.4% - p<0.0001) were compressible vascular injuries (CVI), while among the venous lesions 105 (80.2% - p<0.0001) were classified as compressible. Among non-compressible vascular injuries (NCVI), 30 were arterial lesions (11.6%) and 26 venous lesions (19.8%). The most frequently

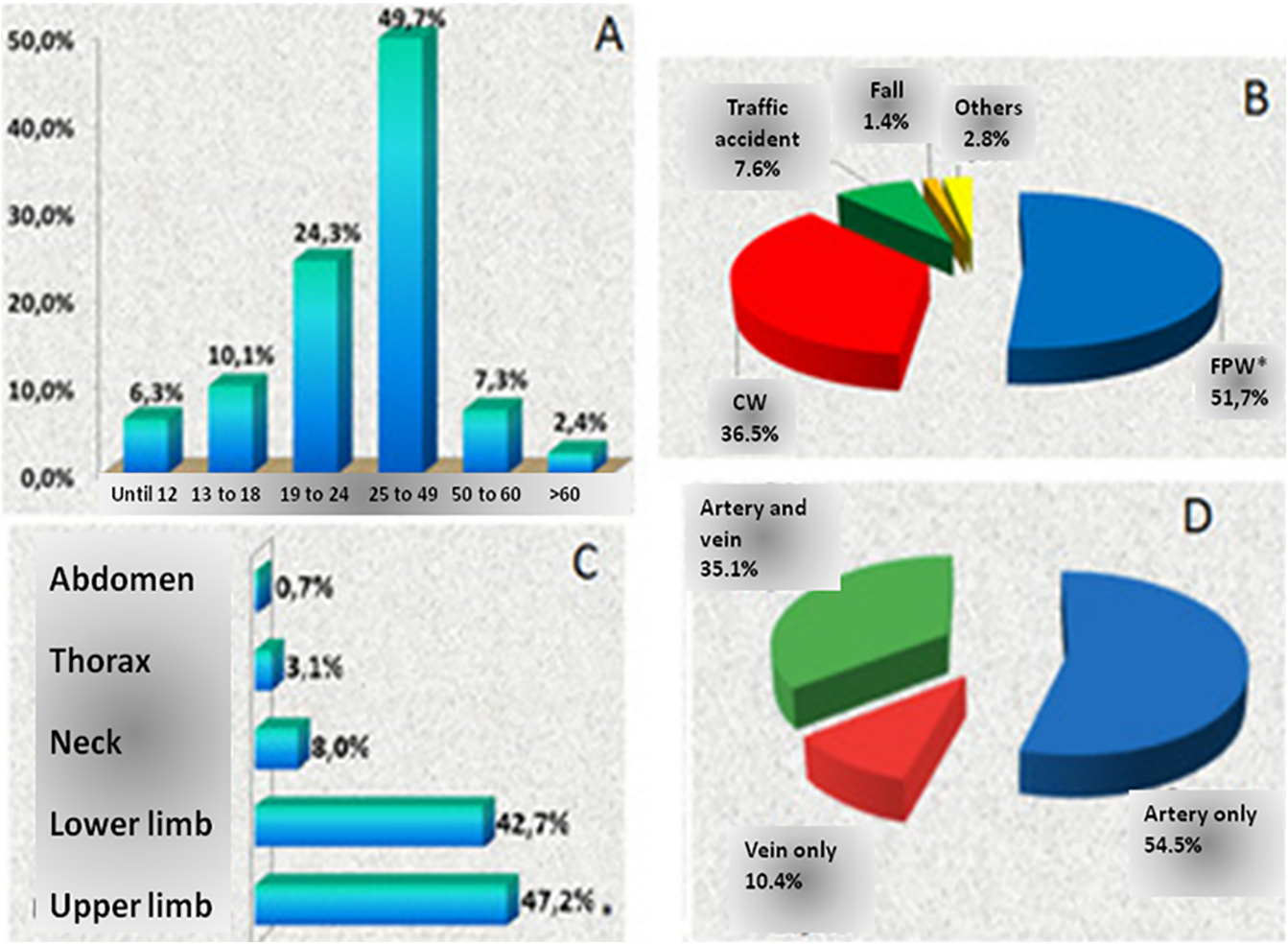

Figure 1. *Distribution of patients according to: A) Age group; B) Trauma mechanism; C) Lesion topography; D) Type of injured vessel. Source: Hospital Metropolitano de Urgência e Emergência. Statistical Test: chi-squared test (χ^2 test); n: Number of patients; p-value ≤0,0001; %: Percentage of cases. FPW: firearm's projectile wound; CW: cutting wounds.*

injured arteries were the brachial ones with 54 cases (18.75% of all arterial lesions - p<0.0001), the superficial femoral with 49 cases (17.01%), and the ulnar with 39 cases (13.54%). The most frequently injured veins were the superficial femoral with 33 cases (25.19% - p<0.0001) and the popliteal vein with 24 cases (18.32%), among the venous lesions (Table 1).

Non-vascular lesions were found in 104 patients (36.1%); fractures were the most common in 55 patients, accounting for 52.8% of all non-vascular lesions. Other concomitant lesions included peripheral nerves (20.19%), thoracic/abdominal lesions (18.2%) and tendon lesions (8.8%).

Surgical techniques are described in table 2. The most frequently used technique to treat arterial lesions was autologous vein graft interposition (37.50% - p<0.0001) and the great saphenous vein was the most commonly used graft (58.8% among all grafts). The superficial femoral (37.2%), brachial (22.54%), and popliteal (19.60%) arteries the most common sites of vein graft interposition. Arterial ligature was performed in 63 cases (23.16%), mainly for ulnar and radial lesions. Synthetic graft was used in three patients. Other surgical procedures for arterial lesions included primary anastomosis (30.15%), thromboembolectomies, and arteriorrhaphies.

Table 1. *Anatomical distribution of vascular injuries.*

Arterial lesions	Arteries	(n)	(%)	Venous lesions	Veins	(n)	(%)
	Axillary	13	5.04		Internal jugular	10	7.63
	Subclavian	7	2.71		Axillary	6	4.58
Non-compressible	Commum carotid	5	1.94	Non-compressible	External jugular	5	3.82
	ONCA	9	3.49		ONCV	6	4.58
	p-value	0.1249			p-value	0.3679	
	Brachial*	54	18.75		Superficial femoral*	33	25.19
	Superficial femoral	49	17.01		Popliteal	24	18.32
	Ulnar	39	13.54		Brachial	19	14.50
	Radial	34	11.81		Basilic	6	4.58
	Popliteal	32	11.11		Common femoral	6	4.58
Compressible	Common femoral	12	4.17	Compressible	Radial	5	3.82
	Posterial tibial	11	3.82		OCV	15	11.45
	Anterior tibial	9	3.13		p-value	<0.0001	
	Deep femoral	6	2.08				
	OCA	8	2.78				
	p-value	<0.0001					
Total of compressible lesions*		228	88.4	Total of compressible lesions*		105	80.2
Total of non-compressible lesions		30	11.6	Total of non-compressible lesions		26	19.8
p-value		<0.0001*		p-value		<0.0001*	

*Source: Hospital Metropolitano de Urgência e Emergência. Statistical test: chi-squared test (χ^2 test); n: Number of patients; * p-value <0.0001; ONCA: Other non-compressible arteries. Each one presented less than five cases (internal carotid, vertebral, external carotid, upper thyroid, ascending aorta, external iliac, pulmonary trunk). OCA: Other compressible arteries. Each one presented less than five cases (tibiofibular trunk, pedicular, and fibular); ONCV: Other non-compressible veins. Each presented less than five cases (external iliac and subclavian); OCV: Other compressible veins. Each one presented less than five cases (anterior tibial, ulnar, deep femoral, cephalic, brachiocephalic trunk, pulmonary vein).*

Table 2. *Surgical techniques used in vascular lesion treatment.*

Arterial lesion treatment	(n)	(%)
Autologous graft*	102	37.50
Primary anastomosis	82	30.15
Ligature	63	23.16
Arteriorrhaphy	18	6.62
Thromboembolectomy	4	1.47
Synthetic graft	3	1.10
Total**	272	100
p-value	<0.0001*	
Venous lesion treatment		
Ligature*	117	95.12
Venorrhaphy	6	4.88
Total**	123	100

*Source: Hospital Metropolitano de Urgência e Emergência. Statistical test: chi-squared test (χ^2 test); ** 272 arterial lesions detected in 288 patients; 123 venous lesions detected in 288 patients.*

Table 3. *Postoperative complications in patients operated due to vascular traumas.*

Postoperative complications **	(n)	(%)
Infection*	49	61.25
Limb ischemia/Thrombosis	21	26.25
Compartmental syndrome	3	3.75
Graft rupture	2	2.50
Stroke	1	1.25
Brachial pseudoaneurysm	1	1.25
Member paresthesia	1	1.25
Acute renal failure	1	1.25
Cerebrospinal fluid leak	1	1.25
Total	80	100
p-value	<0.0001*	
Patients without complications*	222	77.08
Patients with complications	66	22.92
Total	288	100
p-value	<0.0001*	

*Source: Hospital Metropolitano de Urgência e Emergência. Statistical test: chi-squared test (χ^2 test); ** 13 patients presented more than one complication; stroke: acute renal failure.*

For venous injury treatment, ligature was the most used surgical technique (95.12% - p<0.0001). Venorrhaphy was performed in 4.88% of the venous lesions.

The hospitalization period was up to seven days in 52.8% of the cases; in 16% the hospitalization ranged from eight to 14 days; in 16.7%, from 15 to 30 days; and 14.6% of the patients were hospitalized for more than 30 days.

The majority of patients (77.08% - p<0.0001) did not develop postoperative complications and 22.92% presented at least one postoperative complication. Infection was the most common complication (61.25% among all complications - p<0.0001). Postoperative ischemia occurred in 26.25% of patients; compartmental syndrome in 3.75%; and graft rupture in 2.5% (Table 3).

Fifty-five (19.1%) patients were re-operated, mostly due to infectious complications, ischemia, or compartmental syndrome. The most prevalent re-interventions were amputation, corresponding to 33.3% of all re-interventions, debridement (20.0%), skin grafts (11.6%), orthopedic procedures (15.0%), and fasciotomies (8.3%). Amputation was required in 20 patients (6.9% of all patients), 15 had vascular injury in lower limbs (12.20% amputation among patients with lower limb injuries - p=0.0005), and five had in upper limbs (3.68% among patients with upper limb injuries). In the patients submitted to amputation of the lower limbs, the superficial femoral and popliteal were the most affected arteries and veins, whereas in amputations of the upper limbs the brachial artery and vein were the most injured.

Twenty-three patients died, an overall mortality of 7.93%; ten presented isolated arterial lesions corresponding to 43.48% of the deaths; seven had simultaneous arterial and venous lesions (30.43%); and six had only venous trauma (26.09%).

The most frequent lethal arterial lesions were those of common femoral artery, superficial femoral artery, and brachial artery, with four cases (17.39% of patients with lethal lesions) each. The most common lethal venous lesions were those of internal jugular, common femoral, and superficial femoral, with three cases (13.04% of patients with lethal lesions) each. Among the deaths due to concomitant arterial and venous lesions, superficial femoral vessels were the most affected, with three cases (13.04% of patients with lethal lesions) (Table 4).

Three patients died during surgery (13.04%), two of them due to an isolated arterial injury and one due to simultaneous arterial and venous injuries. Seven patients (30.43%) died in the immediate postoperative period, eight patients (34.78%) between the second and the seventh postoperative days, one (4.35%) between the tenth and the 15th postoperative days, and four (17.39%) after the 25th postoperative day. The main cause of death was hypovolemic shock, in 13 patients (56.52% - p=0.0051) (Table 4).

Concerning the travelled distance from the site where the trauma occurred to the hospital, 164 patients (56.9%) came from a distance of 50km or less; 27 (9.3%) travelled between 51 and 100 km; 53 (18.4%) between 101 and 200 km; 32 (11.11%) between 201 and 300 km; and ten (3.4%) came from a distance greater than 300km. It was not possible to determine the travelled distance in the cases of two patients (1.3%) (Table 5).

When unfavorable outcomes were evaluated according to the distance the patient was transported, it was found that amputation incidence was greater for patients who travelled between 201 and 300 km, but this difference did not reach statistical significance (p=0.1793). Hospitalization for more than seven days was more common in patients who needed to be transported for more than 200km, and this longer hospitalization was statistically significant (50.00% - p<0.0001) among those transported over 300km (Table 5). Approximately 11% of the patients (p<0.0001) who needed to be removed for up to 50km died. The percentage of deaths gradually decreased as the distance travelled until the hospital increased. Among patients removed for more than 200km no death was detected. (Table 5).

The correlation between unfavorable outcomes and vascular injury topography revealed one death among patients with abdominal lesions (50.00%), 12 among those with lower limb injuries (9.76%), four among those with cervical trauma (17.39%), two among those with thoracic lesions (22.22%), and seven among those with lethal lesions in the upper limbs (5.15%) (Table 5).

Among the 115 patients who remained hospitalized for more than seven days, one presented abdominal vascular injury, corresponding to 50% of the patients with abdominal vascular injury. Four patients had cervical lesions (17.39%), 59 patients presented lower limb injuries (47.9%), 50 had upper limb injuries (36.76%), and one patient presented thoracic injury (11.11%) (Table 5).

Comparing the rates of amputation and hospitalization of more than seven days, there was a statistically significant difference between lower limb injuries and the other topographies (p=0.0005) (Table 5). The multivariate analysis showed, through the correlation matrix, that the following independent variables were related to death probability (dependent variable): arterial lesion (p=0.0078), cervical topography of the vascular lesion (p=0.0021), and thoracic topography of the vascular lesion (p=0.0336) (Table 6). Once the independent variables correlated to death probability were established, they were analyzed by logistic regression equation and death probability of death was calculated for all combinations among these variables (Table 6).

Table 4. *Anatomical distribution of lethal vascular lesions, cause and time of death.*

Lethal lesions	Arteries	(n)	(%)	Total	
Arterial lesion	Common femoral	4	17.39	10	43.48
	Brachial	4	17.39		
	Superficial Femoral	4	17.39		
	Axillary	1	4.35		
	Common carotid	1	4.35		
	Ascending aorta	1	4.35		
	Ulnar	1	4.35		
	Radial	1	4.35		
	Popliteal	1	4.35		
	Internal carotid	1	4.35		
	Tibiofibular trunk	1	4.35		
Venous lesion	Internal jugular	3	13.04	6	26.09
	Common femoral	3	13.04		
	Superficial femoral	3	13.04		
	Popliteal	2	8.70		
	Pulmonary	1	4.35		
	Brachiocephalic trunk	1	4.35		
	Brachial	1	4.35		
	External iliac	1	4.35		
	Subclavian	1	4.35		
Arterial and venous lesions	Femoral artery and vein Superficial	3	13.04	7	30.43
	artery and vein Popliteal	1	4.35		
	Common femoral artery and vein	1	4.35	23	100.00
	Brachial artery and vein	1	4.35		

Cause and time of death		(n)	(%)
Cause of death	Hypovolemic shock*	13	56.52
	Associated lesions	3	13.04
	Infectious causes	2	8.70
	Brain death	1	4.35
	Non- identified	4	17.39
	Total	23	100.0
	p-value	0.0051*	
Time of death	Intraoperative	3	13.04
	IPO	7	30.43
	2nd to 7th PO	8	34.78
	10th to 15th PO	1	4.35
	20th to 25th PO	0	0.00
	After 25th PO	4	17.39
	Total	23	100.0
Patients who died		23	7.93

*Source: Hospital Metropolitano de Urgência e Emergência. Statistical test: chi-squared test (χ^2 test); * p-value <0.05; PO: Postoperative; IPO: Immediate postoperative.*

Table 5. *Unfavorable clinical outcomes according to: A) distance between the city where the trauma occurred and the referral hospital; B) vascular lesion topography.*

Unfavorable clinical outcomes (A)	Until 50km		From 51 to 100 km		From 101 to 200 km		From 201 to 300 km		More than 300km		p-value
	n=164	(%)	n=27	(%)	n=53	(%)	n=32	(%)	n=10	(%)	
Amputation	8	4.88	3	9.09	4	7.69	4	13.33	1	8.33	0.1793
Death	18	10.98	2	6.06	3	5.77	0	0	0	0	<0.0001*
Hospitalization >7 days	65	39.63	13	39.39	17	32.69	13	43.33	6	50	<0.0001*
Total	91		18		24		17		7		
Unfavorable clinical outcomes (B)	Upper limbs		Lower limbs		Neck		Thorax		Abdomen		p-value
	n=136	(%)	n=123	(%)	n=23	(%)	n=09	(%)	n=02	(%)	
Amputation	5	3.68	15	12.2	0	0	0	0	0	0	0.0005*
Death	7	5.15	12	9.76	4	17.39	2	22.22	1	50	0.0159*
Hospitalization >7 days	50	36.76	59	47.97	4	17.39	1	11.11	1	50	<0.0001*
Total	62		86		8		3		2		

*Source: Hospital Metropolitano de Urgência e Emergência. Statistical test: chi-squared test (χ^2 test). * two patients did not have this type of information in their medical records and seven patients had lesions in more than one topography.*

Table 6. *Correlation matrix of the multivariate analysis and logistic regression equation.*

Correlation matrix		Logistic regression	P-value	*Odds Ratio*
Dependent variable (Y):	Death	Logistic Regression Model	0.0168*	
Independent variables (Xi)	p-value	X1= Neck	0.0060*	9.903
Distance	0.1612			
Neck	0.0021*	X2= Thorax	0.0483*	7.9247
Thorax	0.0336*			
Lower limb	0.9278	X3= Type of artery	0.243	2.3547
Upper limb	0.0652			
Arterial lesion	0.1894	Logistic equation	- 3.3821 + 2.2928 (X1) + 2.0700 (X2) + 0.8564 (X3)	
Venous lesion	0.1736			
Arterial + Venous lesion	0.2567			
Type of Artery	0.0078*			
Type of vein	0.4760			

Source: Hospital Metropolitano de Urgência e Emergência. Odds Ratio: the chance of death is nine times greater in patients with neck injury and seven times higher in those with a thorax injury.

Based on the logistic equation (Table 6), the odds of death are: a) X1=0 (absence of neck injury), X2=0 (absence of thoracic injury), and X3=0 (presence of lesion in non-compressible artery). Probability= 3.29%; b) X1=1 (presence of neck injury), X2=0 (absence of thoracic injury), and X3=0 (presence of lesion in non-compressible artery). Probability (b)= 25.18%; c) X1=0 (absence of neck injury), X2=1 (presence of thoracic injury), and X3=0 (presence of lesion in non-compressible artery). Probability (c)= 21.21%; d) X1=0 (absence of neck injury); X2=0 (absence of thoracic injury), and X3=1 (presence of lesion in compressible artery). Probability (d)= 7.41%; e) X1=1 (presence of neck injury), X2=1 (presence of thoracic injury), and X3=0 (presence of lesion in non-compressible artery). Probability (e)= 72.72%; f) X1=1 (presence of neck injury), X2=0 (absence of thoracic injury), and X3=1 (presence of lesion in compressible artery). Probability (f)= 44.20%; g) X1=0 (absence of neck injury), X2=1 (presence of thoracic injury), and X3=1 (presence of lesion in compressible artery). Probability (g)= 38.80%; h) X1=1 (presence of neck injury); X2=1 (presence of thoracic injury), and X3=1 (presence of lesion in compressible artery). Probability (h)= 86.26%.

DISCUSSION

Trauma is a worldwide repercussion problem and vascular injury is one of the leading causes of death[1,3,5]. Victims of vascular trauma may present injuries in different locations and of varying severity. Lower limbs are frequently affected[3,5,6]. Early diagnosis and treatment of vascular lesions are of paramount importance to avoid limb functional limitation, secondary to prolonged ischemia and death, associated with hypovolemic shock. Limb revascularization performed after six hours of trauma increases the risks of complications[1,5,12]. For this reason, rapid and efficient transportation to the trauma center is necessary [8,11,13].

There are few hospitals with specialized Vascular Surgical team in the Amazon region. The negative influence of long distances to clinical outcomes and surgical treatment had already been published by our group, identifying that distances greater than 300km were associated with an increased risk of amputation and longer hospitalization[3,5]. This impact was confirmed by current research.

The study was conducted so that it would be possible to compare the current casuistry to that of the previous study, in the same institution. Adding both periods, 461 patients with 685 vascular lesions were analyzed.

Municipal ambulances were the main means of transportation of patients (56.6% - p<0.0001). Literature shows that, for long distances, aero-medical transport accelerates the definitive care and reduces morbimortality[12]. Our studies detected only two aerial rescues in six years, demonstrating the low utilization of this resource in our region.

There was a prevalence of male gender (92.7% - p<0.0001), as in the previous study (95.95%)[5]. Other authors have also demonstrated a greater involvement of male patients in cases of trauma associated with violence and motor vehicle accidents[6,14,15]. The age group between 25 and 49 years old was the most affected, with 143 patients (49.7%), similar to what was shown in our preliminary research (54.90% of the total cases)[5]; in both studies there was a statistically significant difference in relation to the other age groups. This finding is corroborated by literature, which also points to this age group as the most economically active one in society, generating a high socio-economic impact[1,2,5].

The analysis of the trauma mechanism helps the surgeon to suspect and investigate injuries in a given scenario[4]. Epidemiology, however, is influenced by regional aspects; in European countries closed traumas are more common, mainly due to automobile accidents[2,4]. Brazilian studies, however, show penetrating trauma as the most frequent ones[1,3-5]. In the present study, 149 patients (51.7% - p<0.0001) had firearm's projectile wound (FPW); 105 patients (36.5%), cutting wounds (CW). Traffic accidents (TA) accounted for 7.6%. This distribution coincides with our preliminary research[5]. Adding data from both studies, we found 231 cases of FPW and 186 of CW.

As in most surveys, limbs were the most affected topography; however, differing from several references that show a greater involvement of the lower limbs, including our previous research, the upper limbs were statistically more affected by vascular lesions in this sample (136 patients/47.2%)[5]. In our previous study, lower limbs lesion were the most common, with 45.66% of the total number of patients[3]. Some authors report the increasing frequency of complex limb trauma in urban centers, probably related to the increase in vehicular traffic and in the access to firearms[2,12,16].

As in our original series, isolated arterial lesions predominated over the venous ones (157 patients x 30 patients)[3,5,6,8,11]. Among the arterial lesions, the compressible ones were the most common, occurring in 228 patients (88.4% - p<0.0001). Many authors point out the superficial femoral and the popliteal arteries as the most affected in the lower limbs and the brachial artery in the upper limbs[6,8,13,17]. In our study, the most statistically damaged artery was the brachial artery (54 patients/18.75%), followed by the superficial femoral artery (49 patients/17.01%). These data diverge from our previous study that showed the superficial femoral and the ulnar arteries as the most affected ones and with equal number of lesions[5]. Considering our professional experience, we know that upper limb injuries are often related to defensive attitude against aggressions with cutting weapons, such as machetes and axes, which are relatively common in the Amazon region.

In 30 patients (10.4%) the venous lesions were found in isolation and in 101 patients (35.1%) associated with an arterial lesion. The most damaged veins were the compressible ones, with the superficial femoral vein being the most affected (11.86%), which is in agreement with our previously published data and with other literature references[1,3,5]. The low incidence of non-compressible venous lesions in our sample is probably related to the fact that, in our institution, jugular, inferior vena cava, and iliac vein injuries are often treated by general surgeons during cervicotomies and exploratory laparotomies (we only computed cases treated by the vascular surgery team).

The most used surgical technique for arterial lesions was the venous graft interposition, with 102 cases (37.50% - p<0.0001), a fact also observed in the previous study; the most commonly used graft was the great saphenous vein, coinciding with other series in literature[5,16,17]. Autologous grafts are considered the most appropriate for vascular repair when the lesion produces loss of arterial tissue, since they present longer patency and lower risk of infection when compared to synthetic ones[5,6].

The vast majority of venous lesions were treated with ligature — 117 cases (95.12% - p<0.0001), as well as in our preliminary study[5]. Although this technique is traditionally used in hemodynamically unstable patients, current researches have been demonstrating the safety of temporary venous shunts as a technique for damage

control[11,13,17-19]. One of the limitations of this work is certainly the lack of patients' physiological parameters at admission.

In relation to our preliminary study, there was a reduction in the occurrence of complications (from 37% to 22.92%). The most common complication was infection, coinciding with other series in literature[3,5,13,17]. Thrombosis, graft rupture, and compartmental syndrome were also detected.

Appendicular vascular trauma greatly increases the risk of amputation[8,13]. In this study, 20 patients were amputated, corresponding to 6.9% of the total number of patients. The amputation rate among patients with lower limb vascular lesions decreased from 26.58% (2011-2013 case series) to 12.20% (current casuistry)[5]. It is known that simultaneous occurrence of fractures, neurological lesions, and venous injuries associated with arterial trauma increases the risk of amputation[6,13,17]. Besides the efficient screening of patients with vascular lesions in the limbs to specialized centers, these factors may contribute to reduce the risk of amputation: adequate use of tourniquets, temporary vascular shunts, fasciotomies, and damage control resuscitation[11,13,15,20]. The present study revealed a low rate of amputation despite the ligature of the vast majority of injured veins, contrary to references which suggest that venous ligature predisposes to limb amputation[11,13].

Overall mortality was of 7.93%, whereas, in the previous study, it was of 6.36%. The main cause of death observed in this study and in the previous one was hypovolemic shock; findings that agree with those of other authors[1,5,7,20]. Literature shows that non-compressible arterial and venous lesions, such as those of the aorta, large thoracic vessels, and inferior vena cava, have a higher death rate, since the rapid exsanguination and the impossibility of compression complicates the treatment in the preoperative phase[11,21,22]. Most die in the trauma scene and, for those who survive, removal time is critical[3,11].

The logistic regression results indicate a significant dependence between death and the occurrence of arterial or vascular lesion in cervical or thoracic topography. The chance of death is nine times higher in patients with cervical vascular injury and seven times higher in patients with thoracic vascular injury. The logistic equation also allowed us to calculate the probabilities of death due to the combination of lesions. For example, a patient presenting as the only lesion the one of a compressible artery, such as the superficial femoral, has a 7.41% chance of death, whereas a patient presenting concomitant arterial lesions in the neck and thorax (for example, a common carotid lesion and a subclavian artery lesion) has a 72.72% chance of death. These evaluations of multivariate analysis and logistic regression were not performed in our preliminary study and therefore they aggregate information to the current work.

In the Amazon region, some locations are geographically isolated and patients need to travel long distances before arriving at the trauma center. The majority of cases came from the metropolitan area of Belém (the capital of Pará state), up to 100km from the hospital, accounting for 64.2% of the total number of patients. When the occurrence of unfavorable outcomes was evaluated according to the distance the patient was transported, we identified that the amputation rate increased according to the distance to the hospital, especially for those who travelled from 200 to 300 km. The previous study also found higher rates of amputation in patients who needed to travel distances greater than 200km.

The highest proportion of deaths occurred among patients who travelled distances up to 50km, a fact already detected in our previous research. As the distance to the hospital increased,

the proportion of deaths decreased and no cases of death were identified among patients removed for more than 200km. The probable explanation for this fact, since both the proportion of cases of prolonged hospitalization and amputation risk increased after longer transfers, is that many patients with vascular injuries, especially non-compressible ones, should evolve to death before reaching the hospital.

Among the limitations of this study, we highlight that our institution is the only one in a vast territorial area to have a specialized vascular surgical team, which, occasionally, causes a delay in patients' treatment (patients may be treated many hours after the trauma), predisposing to unfavorable clinical outcomes. In addition, since this is a retrospective study, some pieces of information such as the time from trauma to hospital arrival and physiological parameters of patients were not found in most cases, making other analyses unfeasible. Also, postoperative evolution was analyzed only until hospital discharge.

R E S U M O

Objetivo: *avaliar dados epidemiológicos dos pacientes operados por trauma vascular em hospital de referência para traumatismos vasculares do Estado do Pará, determinar as variáveis que aumentam o risco de óbito e fazer uma análise comparativa com os resultados previamente publicados pela mesma instituição.* **Métodos:** *estudo retrospectivo analítico realizado através da coleta de dados de pacientes operados por lesões vasculares, entre março de 2013 e março de 2017. Foram analisados dados demográficos e epidemiológicos, como o mecanismo e topografia da lesão, distância entre o local do trauma e o hospital, tipo de tratamento e complicações. Foi feito ainda o estudo de uma matriz de correlação com regressão logística entre as variáveis e a ocorrência de óbito.* **Resultados:** *foram estudados 288 pacientes, com 430 lesões; 92,7% era do sexo masculino, 49,7% entre 25 e 49 anos de idade; 47,2% das lesões foi ocasionada por projéteis de arma de fogo; 47,2% das lesões situava-se nos membros superiores, 42,7% nos membros inferiores, 8% em região cervical, 3,1% torácicas e 0,7% abdominais; 52,8% dos pacientes teve hospitalização por sete dias ou menos. Amputação foi necessária em 6,9% e a mortalidade foi 7,93%.* **Conclusão:** *distâncias superiores a 200km foram associadas à internação prolongada e maior probabilidade de amputação de membros. Foi encontrada correlação significativa entre a ocorrência de óbito e o fato de haver lesão arterial, lesão vascular na topografia cervical e lesão vascular na topografia torácica.*

Descritores: *Ferimentos e Lesões. Lesões do Sistema Vascular. Vasos Sanguíneos. Amputação.*

REFERENCES

1. Soares LT, Bastos CC, Koury Junior A, Pereira AJF. Traumatismos vasculares no Estado do Pará, Brasil, período de 2011 a 2013, e sua relação com variáveis clínicas e demográficas. J Vasc Bras. 2015;14(2):123-32.
2. Bordoni PHC, Santos DMMD, Teixeira JS, Bordoni LS. Deaths from abdominal trauma: analysis of 1888 forensic autopsies. Rev Col Bras Cir. 2017;44(6):582-95.
3. Góes Jr AMO, Rodrigues ADV, Braga FB, Andrade MC, Abib SCV. Vascular trauma in the Amazon region: a two years cases review from a single institution. Health. 2014;6(6):517-30.
4. Parreira JG, Rondini GZ, Below C, Tanaka GO, Pelluchi JN, Perlingeiro JA, et al. Relação entre o mecanismo de trauma e lesões diagnosticadas em vítimas de trauma fechado. Rev Col Bras Cir. 2017;44(4):340-7.
5. Góes Junior AMO, Rodrigues ADV, Braga FB, Andrade MC, Abib SCV. Trauma vascular na Amazônia - o desafio das grandes distâncias. Rev Col Bras Cir. 2015;42(4):244-52.
6. Jaha L, Andreevska T, Rudari H, Adekim B, Ismaili-Jaha V. A decade of civilian vascular trauma in Kosovo. World J Emerg Surg. 2012;7(1):24.
7. Costa CA, Souza JES, Araújo AO, Melo FAO, Costa IN, Klein PH. Traumatismos vasculares pediátricos na cidade de Manaus, Amazonas - Brasil. Rev Col Bras Cir. 2016;43(5):320-6.
8. Perkins ZB, Yet B, Glasgow S, Cole E, Marsh W, Brohi K, et al. Meta-analysis of prognostic factors for amputation following surgical repair of lower extremity vascular trauma. Br J Surg. 2015;102(5):436-50.
9. Góes Junior AMO, Abib SCV, Alves MTS, Ferreira PSVDS, Andrade MC. Venous shunt versus venous ligation for vascular damage control: the imunohistochemical evidence. Ann Vasc Surg. 2017;41:214-24.

10. Governo do Estado do Pará. Secretaria de Estado de Turismo. O ordenamento turístico do estado do Pará, 2016. Disponível em: <http://setur.pa.gov.br/o-ordenamento-turistico-do-estado-do-para>. Acessado em: 11 jan 2018.
11. Markov NP, DuBose JJ, Scott D, Propper BW, Clouse WD, Thompson B, et al. Anatomic distribution and mortality of arterial injury in the wars in Afghanistan and Iraq with comparison to a civilian benchmark. J Vasc Surg. 2012;56(3):728-36.
12. Schweitzer G, Nascimento ERP, Nascimento KC, Moreira AR, Amante LN, Malfussi LBHM. Intervenções de emergência realizadas nas vítimas de trauma de um serviço aeromédico. Rev Bras Enferm. 2017;70(1):54-60.
13. Feliciano DV. Pitfalls in the management of peripheral vascular injuries. Trauma Surg Acute Care Open. 2017;2(1):e000110.
14. DuBose JJ, Salvage SA, Fabian TC, Menaker J, Scalea T, Holcomb JB, Skarupa D, Poulin N, Chourliaras K, Inaba K, Rasmussen TE; AAST PROOVIT Study Group. The American Association for the Surgery of Trauma PROspective Observational Vascular Injury Treatment (PROOVIT) registry: multicenter data on modern vascular injury diagnosis, management, and outcomes. J Trauma Acut Care Surg. 2017;78(3):215-22. Erratum in: J Trauma Acute Care Surg. 2015;78(3):657.
15. Figueiredo Junior RI, Carvalho MV, Lima GM. Trauma pediátrico devido a acidente veicular em via de grande tráfego. Einstein. 2012;10(1):29-32.
16. Brasil. Ministério da Saúde. Departamento de informática do SUS. Morbidade hospitalar do SUS por causas externas - por local de internação - Brasil (Internet). Brasília; 2017. Disponível em: http://tabnet.datasus.gov.br/cgi/deftohtm.exe?sih/cnv/fiuf.def. Acessado em: 11 jan 2018.
17. Jawas A, Abbas AK, Nazzal M, Albader M, Abu-Zidan FM. Management of war-related vascular injuries: experience from the second gulf war. World J Emerg Surg. 2013;8(1):22.
18. Rasmussen TE, Dubose JJ, Asensio JA, Feliciano DV, Fox CJ, Nuñez TC, Sise MJ; Military Liaison Committee of the American Association for the Surgery of Trauma. Tourniquets, vascular shunts, and endovascular technologies: esoteric or essential? A report from the 2011 AAST Military Liaison Panel. J Trauma Acute Care Surg. 2012;73(1):282-5.
19. Evans C, Chaplin T, Zelt D. Management of major vascular injuries neck, extremities, and other things that bleed. Emerg Med Clin North Am. 2018;36(1):181-202.
20. Roberts DJ, Bobrovitz N, Zygun DA, Bail CG, Kirkpatrick AW, Faris PD, et al. Indications for use of thoracic, abdominal, pelvic, and vascular damage control interventions in trauma patients: a content analysis and expert appropriateness rating study. J Trauma Acute Care Surg. 2015;79(4):568-79.
21. Daou B, Alkhalili K, Chalouhi N, Al-Saight F, Tjoumakaris S, Rosenwasser RH, et al. Epidemiology, pathophysiology, and treatment of traumatic cervical vascular injury. Semin Spine Surg. 2017;29(1):27-33.
22. Rappold JF, Bochicchio GV. Surgical adjuncts to noncompressible torso hemorrhage as tools for patient blood management. Transfusion. 2016;56 Suppl 2:S203-7.

Received in: 06/09/2018
Accepted for publication: 07/03/2018
Conflict of interest: none.
Source of funding: none.

Mailing address:
Adenauer Marinho de Oliveira Góes Junior
E-mail: adenauerjunior@gmail.com
goesjunior@ufpa.br