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The predictors of poor outcomes in patients with femoral artery injuries

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Abstract. – PURPOSE: This study investigated the predictors of poor outcomes, including limb loss and death, in patients with femoral artery injuries.

PATIENTS AND METHODS: The study included 158 patients aged 2-82 (mean age 28.4 ± 16.5) with femoral arterial injury (common, deep, and superficial femoral artery) that were treated surgically between 2000 and 2010. Isolated venous injuries were excluded. Demographic and clinical data of the patients, including age, gender, admission time, pulse rate and blood pressure, hematocrit value, reason of injury, associated injury, and Mangled Extremity Severity Score (MESS) were recorded.

RESULTS: Of the 158 patients, the death and amputation rates were 5.7% (9) and 5.1% (8), respectively. In logistic regression analysis, four variables (pulse rate, MESS, hematocrit, and bone trauma) were found to be independent predictors for poor outcomes. The Odd's ratios and confidence interval values of these variables were as follows: 7.24 (1.94-26.92), 21.75 (5.41-87.48), 5.93 (3.04-11.54) and 7.46 (2.09-9.56), respectively.

CONCLUSIONS: The MESS value, presence of bone fracture, hematocrit, and pulse rate on admission are predictive risk factors for poor outcomes in patients with femoral artery injury. Therefore, in these patients, prompt intervention by experienced surgeons is crucial for limb salvage and decreased mortality.

Key Words:
Femoral artery injuries, Predictors, Death and amputation.

Introduction

The prevalence of peripheral vascular injuries is increasing steadily throughout the world and they now comprise 2-3% of all cases of trauma. Femoral artery injuries (FAIs) constitute 20-72% of the peripheral arterial injuries. This complex trauma may lead to extremity dysfunction, amputation, and even to death if not diagnosed promptly and treated with the appropriate surgical approach. Although penetrating arterial injuries are usually immediately diagnosed, the diagnosis of the vascular injuries caused by blunt trauma may be delayed when the clinical findings are not adequate for a prompt diagnosis[1-3].

Wartime surgery has greatly advanced the treatment of vascular injuries. In the early years of vascular surgery, ligation was the only treatment method. Thus, the rate of amputations performed due to vascular injuries has decreased from 53% to 1.5% since 1940s years[4-6]. The frequency of terrorist attacks and criminal events, as well as road accidents, has put vascular injuries under the spotlight again. In the present study, the results following vascular injuries and the factors leading to poor outcomes were evaluated based on a selection of patients treated for FAI during the last 10 years.

Patients and Methods

Data Collection

In a retrospective study design, data from 158 patients between the ages of 2 and 82 (mean age: 28.4 ± 16.5) were included in the study. These patients were admitted with FAIs (common, deep, and superficial femoral arteries) to the Dicle University School of Medicine, Department of Cardiovascular Surgery, Diyarbakir, Turkey between November 2000 and July 2010. Patients with isolated venous injuries, traumatic amputations, or those who had undergone surgical amputations on admission because of severe tissue defect were excluded from the study. The patient files were obtained from the Hospital registry.

The demographic and clinical data of the patients, including age, gender, and admission date, admission data (the heart rate, blood pressure,

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and hematocrit (Htc) values on admission), the reason of injury, any associated injuries, and the Mangled Extremity Severity Score (MESS) data were recorded. In addition, the hard signs (pulsatile bleeding, expansive or pulsatile hematoma, murmur or trill, diminished or absent distal pulse, distal ischemia or pain, pallor, paralysis, paresthesia, and poikilothermia) and soft signs (stable hematoma, unexplained or transient hypotension, proximity injury or peripheral nerve deficit, and history of any bleeding that subsided spontaneously) for FAI were recorded. Finally, the duration of the hospital stay and the treatment outcomes, including healing, amputation, and death, were recorded.

Treatment of Arterial Injuries

Rapid fluid replacement was applied to patients who were admitted to the Emergency room with hypotension (blood pressure < 90 mmHg). Central venous catheters were placed in all the patients with confirmed FAIs. Femoral angiography was performed to confirm the suspected FAI and/or to determine the extent of the injury. All surgical interventions were carried out under general anesthesia. Patients were started on systemic antibiotherapy in the perioperative period.

In patients with associated bone injuries, vascular repair was followed by bone fixation. Before the placement of the vascular clamp, 100 IU/kg of standard heparin was administered by intravenous push. During the operation, the proximal and distal ends of the artery and the vein were primarily suspended and 500 IU of heparin was applied to the proximal and distal ends of the artery. The proximal and distal lumen of the artery was checked and an embolectomy was performed if necessary.

End-to-end anastomosis was the preferred method in patients with no significant vascular segment loss. In other cases, interposition of a saphenous graft obtained from the contralateral limb was the primarily preferred method. In cases in which the saphenous vein was not found or in the presence of complications like shock, acidosis, or hypothermia, a polytetrafluoroethylene (PTFE) graft was used. Primary repair or end-to-end anastomosis was performed in cases of incomplete transection. Primary repair was also the preferred method in angiography-related injuries. In deep FAIs, ligation or primary repair was performed. Low molecular weight dextran (250-500 ml/day) and anticoagulant therapy (100 IU/kg/day) was applied during the postoperative period (24 hours). Doppler ultrasonography was performed in all the cases and, when necessary, an angiography was performed before discharge.

Statistical Analysis

Mean, standard deviation (SD), and median values were calculated for continuous and discrete variables. All categorical variables were presented as number of patients and percentages. Categorical variables were analyzed using the Chi-square test. Binary logistic regression analysis was used to determine the risk variables. All variables were included in the backward stepwise procedure. Two-sided p values were considered statistically significant at a value of $p \leq 0.05$. The statistical analyses were carried out with the help of the SPSS 15.0 for Windows statistical package (SPSS Inc., Chicago, IL, USA).

Results

In this study, 158 patients (145 males, 91.8%; 13 females, 8.2%; mean age 28.4 ± 16.5) were investigated. The median Hospital stay was 11 (2-45) days. The injuries were located in the common femoral artery in 33 (20.8%) patients, the superficial femoral artery in 104 (65.8%) patients, and the deep femoral artery in 21 (13.4%) patients. The demographic data and injury-related findings on admission, as well as the surgery findings are presented in Table I and Table II.

The results of the logistic regression are presented in Table I. Of the variables, 4 (the heart rate, MESS, Htc, and bone trauma) were found to be significant and included in the logistic regression model ($p < 0.001$). The Odd's ratio and confidence interval values of the heart rate, MESS, Htc, and bone trauma were 7.24 (1.94-26.92), 21.75 (5.41-87.48), 5.93 (3.04-11.54), and 7.46 (2.09-9.56), respectively.

Mortality and Amputations

In this study, 9 patients died during the Hospital stay (5.7% in-hospital mortality). Causes of death included additional abdominal and/or thorax trauma in 5 patients, postoperative multiorgan failure in 2 patients, and sepsis in 2 patients. The amputation rate was 5.1% (8 amputations) during the study period. All of these events were cases of delayed amputation (traumatic amputations were excluded from the investigation). The results of the Chi-Square analysis of the risk factors associated with poor outcomes are presented in Table III.

Table I. Clinical and demographic features of the patients.

Variable	Number, (%)	Mean + SD
Age (years)	–	28.4 ± 16.5
Male gender	145 (91.8 %)	
MESS score		
≤ 4	119 (75.3%)	3.9 ± 1.1
> 4	39 (24.7%)	
Associated injuries		
No	52 (32.9 %)	
Vein	64 (40.5%)	
Nerve	15 (9.5 %)	
Bone fracture	27 (17.1 %)	
Complex	32 (20.2 %)	
Reason of injury		
Firearm	58 (36.7 %)	
Stab	74 (46.8 %)	
Iatrogenic	10 (6.3%)	
Blunt	16 (10.1%)	
Blood pressure (mmHg)		
< 90	63 (39.8%)	103 ± 34
> 90	95 (60.1%)	
Pulse rate (bpm)		
< 120	45 (28.5%)	104 ± 32
90-120	74 (46.8%)	
> 120	39 (24.7%)	
Hard sings		
Yes	139 (87.9%)	
No	19 (12.3%)	
Haematocrit at admission		
> 35%	35 (22.1 %)	30.4 ± 5.7
25-35%	85 (53.8 %)	
< 25%	38 (24.1%)	
Admission time (hours)		
< 8	117 (74.1 %)	6.7 ± 2.8
8-72	27 (17.1 %)	
> 72	14 (8.8%)	

Presence of Hard Signs

Of the 158 patients, 139 had at least one hard sign of arterial injury. The prevalence of the hard signs was similar in two groups.

Reasons for Injury

The most common reason for injury was stab wounds (n = 74, 46.8%). In addition to stab wounds, 58 patients (36.7%) were admitted with gunshot wounds, 16 (10.1%) had blunt trauma (road accidents), and 10 (6.3%) patients had iatrogenic femoral injuries (femoral catheterization). Amputation or death had a significantly higher rate among patients with blunt injuries compared to those with other types of injury (p = 0.001). However, the regression analysis revealed no relationship between the type of the injury and the poor outcome.

Admission Time

The mean admission time was 5.8 ± 2.8 hours. The admission time was less than 6 hours for 117 of the patients. Late or early admission was not observed to have an effect on the outcome.

MESS

The mean MESS score was 3.92 ± 1.1. The mean MESS score was significantly higher in patients with a poor outcome than those who achieved complete recovery (5.47 ± 0.8 vs. 3.73 ± 0.9, respectively; $p < 0.001$). The rate of poor outcomes was significantly higher in the patients with higher MESS scores (> 4) compared to those with lower MESS scores ($p <$ 0.001). A higher MESS score was associated with a poor outcome in the multivariate analysis (Table IV).

Table II. Factors having effect on poor outcome in FAI.

	Number	%
Types of arterial injuries		
Complete transection	47	29.7
Partial transection	62	39.3
Thrombosis	25	15.8
Pseudoaneurysm	13	8.3
Spasm	3	1.9
Intimal disruption	5	3.1
Arteriovenous fistula	3	1.9
Method of arterial repairs		
Reverse saphenous vein greft	52	32.9
End to end anastomosis	23	14.5
Primary repair	59	37.4
PTFE Conduit	7	4.4
Ligation	17	10.8
Additional perioperative procedure		
Thoracotomy	4	2.5
Laparotomy	7	4.4
Embolectomy	39	24.7
Culf fasciotomy	36	23
Thigh fasciotomy	16	10
Femur fracture repair	26	16.5
Outcomes		
Healing	141	89.2
Amputation	8	5.1
Death	9	5.7

Hematocrit

The mean Htc was calculated as 32.4 ± 5.7%. The mean Htc levels of the patients who died or underwent an amputation were significantly higher than those who achieved full recovery (27.2 ± 3.2 vs. 36.6 ± 4.3, respectively; $p < 0.001$). In 38 patients (24.1%), the Htc value measured was below 25%.

Pulse Rate

The mean heart rate of the patients was 104 ± 32 bpm. The percentage of death or amputations was significantly higher in patients with a high pulse rate (> 120 bpm) compared to those with lower pulse rates ($p = 0.002$).

Associated Injuries

Vein injuries constituted the most commonly observed associated injury type (n = 64, 40.5%). Associated injuries were significantly related to poor outcomes ($p = 0.002$). The presence of bone fractures together with the femoral injury led to the highest percentage of poor outcomes in this category ($p < 0.001$, Odd's ratio (OR): 7.46, CI: 2.09-9.56).

Type of Injury on Exploration

The most common type of injury was the partial transection of the femoral artery (n = 62, 39.3%). No relationship was observed between the type of the injury and a poor outcome.

Repair Methods

Of the patients, 59 (37.4%) underwent primary repairs, 52 (32.9%) patients had interposition vein grafts, 7 patients (4.4%) received prosthetic interposition grafts, 23 (14.5%) patients underwent end-to-end anastomoses, and 17 patients (10.8%) had ligations.

Ligation or a primary repair was the preferred method in patients with deep FAIs. Although a significant difference was observed between the repair methods in terms of the outcome in the Chi-Square analysis, this was not the case in the regression analysis ($p = 0.03$).

Adjunctive Surgical Procedure

A thoracotomy or tube thoracostomy was performed in 4 patients and laparotomies were performed in 7 patients. In 28 patients, 16 thigh fasciotomies and 36 calf fasciotomies were performed. In addition, 27 patients underwent bone fracture repairs.

Infection Rate

Local wound infections occurred in 17 patients (11%), all of which were associated with bone fractures.

Discussion

In this investigation, our caseload of FAIs is presented. In 252 patients with lower extremity trauma, 158 FAIs were diagnosed, which constitute a prevalence of 62.7%. In addition, we found the rate of amputations and mortality as 5.1% and 5.7%, respectively.

The risk variables for poor outcomes, including death and amputation, were evaluated using the logistic regression models. According to these results, four main variables, namely the MESS, bone trauma, heart rate, and Htc were associated with a high risk for a poor outcome. The Odd's ratios of these four variables were 21.75, 7.46, 7.24, and 5.93, respectively.

Vascular injuries mainly occur in the young male population all over the world[3,7-8]. Our study agrees with the literature in terms of the patients' ages and genders. Femoral vessel injuries occur rather frequently and they may account for 70% of all the peripheral vascular injuries. Although these injuries have a lower

Table III. The results of the Chi-Square analysis of the patients.

Variable	Number of injuries	No of poor outcome and percent	*p* value
Age			
≤ 40	134	15 (11.2%)	NS
> 40	24	2 (8.3%)	
Gender			
Men	145	16 (11%)	NS
Women	13	1 (7.7%)	
Reason of injury			
Firearm	58	11 (18.9%)	0.001
Stab	84	2 (2.3%)	
Blunt	16	(25%)	
Hypotension (mmHg)			
Yes	63	11 (17.4%)	0.027
No	95	6 (6.3%)	
Pulse rate (bpm)			
> 120	45	11 (24.4%)	0.002
90-120	74	3 (4.1%)	
< 90	39	3 (7.7%)	
Haematocrit (%)			
≤ 25	38	11 (28.9%)	< 0.001
> 25	120	6 (5%)	
Hard signs			
Yes	139	15 (10.8%)	NS
No	19	2 (10.5%)	
Associated injuries			
No	52	1 (1.9%)	0.002
Vein	64	5 (7.8%)	
Nerve	15	4 (26.7%)	
Bone fracture	27	7 (25.9%)	
Type of injury			
Complete transection	47	10 (21.2%)	0.018
Partial transection	62	3 (4.8%)	
Others	49	4 (8.1%)	
Admission time (hours)			
< 8			
> 8	117	7	NS
	41	10	
MESS score			
≤ 4	119	2 (1.7%)	< 0.001
> 4	39	15 (38.4)	
Method of arterial repairs			
Reverse saphenous vein greft	52	10 (19,2)	0.03
End to end anastomosis	22	4 (18.2%)	
Primary repair	60	1 (14.3%)	
PTFE Conduit	7	2 (3.3%)	
Ligation	17	0	

Table IV. The results of logistic regression analysis.

Variables	β	S.E	Wald	OR (95% CI)	p
Pulse	1.98	0.67	8.73	7.24 (1.94-26.92)	< 0.001
MESS	3.08	0.71	18.81	21.75 (5.41-87.48)	< 0.001
Htc	1.78	0.34	27.40	5.93 (3.04-11.54)	< 0.001
Bone-trauma	2.01	0.65	9.56	7.46 (2.09-9.56)	< 0.001

β: Regression coefficient; S.E.: Standard Error; Wald: Wald Statistics; OR: Odd's Ratio; CI: Confidence Interval; *p*: Significant level.

mortality rate, they may still lead to morbidity and long-term disability[4,9,10]. Age and gender were not observed to be factors associated with the outcome of the treatment.

The prevalence of FAIs varies depending on the military or civilian background of the population. Makins[9] reported on a British review comprising of 366 FAIs in 1,202 patients (31%) during World War I. Similarly, during World War II, De Bakey and Simeone[4] reported the percentage of FAIs as 21%. According to the data based on the Vietnam War, the prevalence of FAIs was 35%[1]. Feliciano et al[11] reported on 220 patients who sustained lower limb vascular injuries, 142 of which were femoral injuries, constituting a 65% percentage. In our study, the prevalence of FAIs was similar to the rates reported in the literature.

Penetrating trauma constitutes the majority of the femoral vessel injuries in the literature. Cargile et al[3] reported an 88% percentage of penetrating injuries and a 12% of blunt trauma. Similarly, Feliciano et al[11] and Asensio et al[12] reported the most common reason of FAIs as penetrating trauma, with prevalence of 81% and 86%, respectively. Conversely, in developed countries, such as the Northern European countries, blunt trauma is the most common reason for vascular injuries[7]. Out of our 158 patients, 142 were admitted with penetrating femoral injuries due to gunshot wounds, stab wounds, and iatrogenic injuries. The high prevalence of these penetrating injuries (89.9%) may be associated with the frequency of terror attacks and violence in Southeast Region of Anatolia.

Although the ischemic time is considered as an important factor affecting the poor outcomes, this point was not clearly demonstrated. Some Authors have claimed that the severity of tissue ischemia depends not only on its duration, but also on the state of the arterial injury, the efficiency of the collateral circulation, and the extent of tissue damage. Therefore, no correlation between the admission time and the treatment outcome was observed[13].

The clinical status of the patients with a high heart rate may change to cardiopulmonary arrest because of severe hemorrhage. Hypotension, severe tachycardia, and shock may occur. Cargile et al[3] reported the appearance of hypotension (< 90 mm Hg) and shock as 37% and 40%, respectively. In the study by Asensio et al[12], 42 (21%) patients presented with hypotension while 4 (1%) patients were admitted with cardiopulmonary arrest. In our study, 63 out of 158 patients had hypotension (39.8%) and 12 patients were admitted with cardiopulmonary arrest. In 2 patients (1.27%), a thoracotomy had to be performed in the emergency room. Eventually, 4 out of the 12 patients with cardiopulmonary arrest survived.

The role of angiography in the diagnosis of femoral injuries is influenced by the proportion of hard and soft signs on admission. In the studies by Feliciano et al[11] and Cargile et al[3], the percentages of preoperative angiography were reported to be relatively higher (63% and 45%, respectively) because the majority of patients were admitted with soft signs. In the study by Asensio et al[12], angiography was 15%. In our caseload, 139 of the 158 (88%) patients had at least one hard sign of femoral injury. Therefore, the ratio of the angiographies required was similar to the report of Asensio et al (29 patients, 18%).

Hafez et al[14] have shown that the presence of compound fractures in association with arterial injuries of the lower limbs lead to the highest limb loss among the associated injuries. Similarly, in our study, associated bone fracture was a predictive factor for a poor outcome although it is a component of the MESS system. It is possible that combined bone and vascular injuries are associated with extensive soft tissue and nerve damage[15]. The MESS score, including the degree of the skeletal and soft tissue injury, limb ischemia, shock, the patient's age, and the time elapsed since the injury, has been used to make the decision on amputation. Amputation is recommended in patients with a MESS score[16] greater than 7. In this study, patients with MESS scores higher than 7 were excluded from the study. However, a MESS score greater than 4 was also observed as a predictive risk factor for poor outcomes in the logistic regression model.

The Htc value, pulse rate, and hypotension are factors related to the level of the hemorrhaging. Lower Htc levels and higher heart rates were detected as predictive factors for a poor outcome. It is possible that hypotension is not a predictive factor on its own since it is a component of the MESS score, along with the other factors.

Hafez et al[14] found arterial transection as a predictive risk factor leading to limb amputation. We observed a significant difference between the types of the arterial injuries in terms of poor outcomes. However, this difference did not prove to be a risk factor for a poor outcome in the multivariate analysis. This may be related to the seg-

ment where the arterial injury is located (solely FAI versus femoral, popliteal, and tibial arterial injuries in combination).

Primary repair is preferred for mild injuries. If a conduit is necessary, a reverse saphenous vein graft is the best choice because of its high rate of long-term patency and low appearance of infection. As for the PTFE, it is used in patients with shock, acidosis, hypothermia, and coagulopathy, as well as in patients who require large transfusions or patients with venous and bone injuries[2,12]. Although Martin et al[2] used PTFE in 55 patients (53%) and Asensio et al[13] in 10% of their patients, Cargile et al[3] used them in 0.5% of their patients. We found that percentage use of PTFE was 4.4% of the patients. In 4 of these, there was no appropriate saphenous vein, while the remaining 3 patients were in shock or acidosis.

Ligation may be a treatment option in younger patients in which surgical repair is not possible[17]. For our patients, 12 out of 21 with deep FAIs, with or without superficial FAI, were treated with ligations. No further problems were observed in these patients. Thus, ligation may be a logical treatment option in patients with deep FAI.

In cases of venous injuries associated with arterial injuries, a repair is the first choice of treatment. However, in high-risk patients (e.g., shock, multitrauma, or acidosis), ligation may be preferred. Timberlake et al[18] have shown that venous repair is the ideal procedure, but not mandatory in patients with combined arterial and venous injuries in order to salvage the lower limb. In our study, 5 out of 64 patients with combined arterial and venous injuries were treated through venous ligations. Of these, 3 patients experienced no further problems, while 1 had a temporary edema in the extremity and another developed a deep vein thrombosis in the seventh postoperative day.

The risk of compartment syndrome increases in late admissions since skeletal muscle necrosis begins within 6 hours. In such patients, a fasciotomy at the appropriate time point may reduce the risk of complications[19]. Field et al[20] reported that prophylactic fasciotomy reduced the risk of limb loss in patients with an ischemic time longer than 6 hours or with associated arterial or venous injury. However, several reports have suggested that the procedure should be performed only when necessary following vascular repairs[2,3,21]. We did not prefer to perform prophylactic fasciotomies. In 19 patients, a fasciotomy was carried out after the vascular repair; in 7 patients, late fasciotomies were performed.

The basic limitation of this work is the relatively small number of the study population. A higher percentage of death or amputation would render our findings stronger in comparison to the other studies on the subject.

Conclusions

In this study, it has been shown that the MESS score, the presence of bone fractures, the Htc level, and heart rate on admission are predictive risk factors for poor outcomes in patients with FAIs. Therefore, prompt intervention by experienced surgeons is crucial in order to salvage the limb and decrease the mortality in these patients.

Conflict of Interest

None declared.

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