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Research Article

THE RISK FACTORS FOR ACUTE RENAL FAILURE IN PATIENTS UNDERGOING EMERGENCY SURGERY FOR ARTERIAL VASCULAR INJURY DUE TO LOWER EXTREMITY TRAUMA

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ABSTRACT

Background: Acute renal failure is a common complication in trauma patients and can lead to significantly poorer outcomes. Although the prognosis has improved in recent decades, the mortality of acute renal failure remains considerable. In this study, we investigated the risk factors associated with acute renal failure in patients treated urgently for lower extremity arterial vascular injury.

Material-Methods: Between 2009 and 2019, 98 patients underwent surgical intervention for the diagnosis of arterial injury due to trauma to the lower extremity. We conducted a systematic literature search of studies on acute renal failure according to KDIGO (Kidney Disease Improving Global Outcomes), the most recently evolved scoring system incorporating RIFLE and AKIN criteria (KDIGO guideline 2012) in trauma patients. We investigated and analyzed the risk factors that may cause acute renal failure using logistic regression analysis.

Results: The penetrating trauma was more frequent than blunt (43.9 % vs. 34.7 %). In 21 cases (21.4 %), road traffic crash was the cause of injury. Multi-organ failure was seen in 2 patients. These patients died on the 7th and 11th days. Hospital mortality was observed in 6 of 98 patients. The mean duration of stay in intensive care unit was 5.1±2.7 days, while total hospital stay was 16.7±3.1 days. Renal dysfunction showing renal destruction findings were seen in 24 patients. Hemodialysis was performed in 12 patients due to renal failure. Age >50, ISS> 20, MESS> 7, blood and blood-product transfusion > 1000cc, volume loading with hydroxyethyl starch, hypotension on admission, hemodynamic shock, and intense soft tissue-muscle trauma significant risk factors for the development of acute renal failure in the logistic regression analysis.

Conclusions: Vascular trauma is one of the medical problems that require emergency surgery. Renal damage is a frequent complication following trauma and is associated with prolonged hospital length of stay and increased mortality. These patients should be closely monitored for renal failure and there should be no delay in hemodialysis when the indication is established.

INTRODUCTION

Although vascular traumas can often be treated without problems in recent years, they may cause dramatic, pathological and systemic undesirable consequences. Acute renal failure (ARF) is a common cause of organ failure in vascular trauma patients who survive their initial injuries, and is independently associated with poor outcomes and higher mortality rates. Mortality rates are usually due to systemic tissue damage and can be seen at about 20 % (1,2). In these patients, multidisciplinary approaches are frequently needed. Lower extremity arterial injuries are a common cause of morbidity and mortality in both civilian and military settings.

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They are caused by a penetrating trauma or injury to the limb with a firearm, and have mortality rates of approximately 1.5% to 10%, while limb loss rates approach 16 % (2). The incidence of vascular trauma differs between countries in rural and urban areas. It is usually high in gunshot wounds. In Europe, blunt and penetrating injuries are generally distributed, while penetrating injuries are higher in the United States of America. Approximately 75 % of all vascular injuries limbs and more than 50 % are localized in the legs. In addition to bleeding, lower extremity artery injuries can cause life-threatening and multi-organ complications due to insufficiency of perfusion. Injured patients are at risk of developing ARF, which is associated with increased morbidity and mortality.

In this study, we retrospectively investigated and evaluated the indications, incidence and risk factors of postoperative renal damage in patients undergoing arterial repair due to lower extremity vascular trauma.

MATERIAL AND METHODS

The study included 98 patients who were subjected to lower extremity trauma. The mean age of our study group was 42.2±7.1 years (average: 28-61 years). The male to female ratio was 66/32. The preoperative characteristics of the patients are summarized in Table-1.

In addition to bleeding, pulse monitoring, infection and other organ system functions, our patients were followed up in terms of renal dysfunction (as a target of our current study) in the postoperative period. The patients were evaluated for ARF, renal dysfunction and hemodialysis needs. All patients with ARF, except 2 patients, required hemodialysis. During hospitalization, hemodialysis was performed by inserting a subclavian catheter. In some patients, hemodialysis was terminated after several sessions, while in some patients the need for hemodialysis continued. These patients were discharged by creating an arteriovenous fistula in addition to the subclavian dialysis catheter. After discharge, they were followed-up by taking the hemodialysis program. Diagnosis of ARF and hemodialysis indications were determined according to the following conditions:

Acute renal failure diagnosis: Renal injury is defined as an abrupt (within 48 hours) reduction in renal function based on an elevation in serum creatinine level, a reduction in urine output, the need for renal replacement therapy, or a combination of these factors. It is classified in three stages. ***Stage I*** (Increase ≥ 0.3 mg per dL (26.52 μmol per L) or ≥ 1.5- to two fold from baseline in serum creatinine level, < 0.5 mL per kg per hour for more than six hours in urine output). ***Stage II*** (Increase > two- to threefold from baseline in serum creatinine level, < 0.5 mL per kg per hour for more than 12 hours in urine output). ***Stage III*** (Increase > threefold from baseline or ≥ 4.0 mg per dL (353.60 μmol per L) with an acute rise of at least 0.5 mg per dL (44.20 μmol per L) in serum creatinine level, < 0.3 mL per kg per hour for 24 hours or anuria for 12 hours in urine output and renal replacement therapy required).

Indications for hemodialysis: Creatinine clearance levels<20–25 mL/min/1.73 m^2, creatinine levels > 10 mg/dL, and blood urea nitrogen (BUN) > 100-120 mg/dL., lung congestion and peripheral edema supporting hypervolemia, symptoms of uremia: nausea, vomiting, mental degradation, seizure, progressive volume overload, severe metabolic acidosis with oliguria/anuria (plasma pH<7.2, bicarbonate level<15 mmol/L), hyperkalemia (indication of emergency dialysis with serum potassium above 7 mEq/L). For ARF criteria and hemodialysis indications, in our study, we used KDIGO (Kidney Disease Improving Global Outcomes), the most recently evolved scoring system incorporating RIFLE (Risk, Injury, Failure, Loss and End Stage) and AKIN (Acute Kidney Injury Network) criteria (KDIGO guideline 2012), in line with most recent literature looking at acute renal failure incidence (3-6). Because many of our patients had combined trauma patients, injury severity score (ISS) and mangle extremity severity score (MESS) points were also performed. The mean ISS was defined on the basis of the accumulation of the three squared abbreviated injury scale (AIS) scores ($ISS=A^2+B^2+C^2$, where A, B, and C are the AIS scores of the three most frequently injured body areas). It is a scoring system that allows numerical calculation and identification of the total severity of injury in people with injuries to more than one body area (7,8). MESS was defined on the basis of the skeletal/soft tissue injury score, limb ischemia, shock, and age (8,9). In addition to many preoperative and operative parameters (age, gender, hypotension on admission, diabetes mellitus, smoker habits, types of injury, bleeding and fluid replacement etc.), we investigated whether ISS and MESS points are a risk factor for the acute renal destruction. The study was approved by the institutional review board of Regional Training and Research Hospital. A procedure-oriented informed consent form was signed by each patient. Hospital Ethical Committee also approved the study. All procedures were performed in accordance with the Declaration of Helsinki.

Statistical Analysis

Statistical analysis was performed using SPSS version 18.0 (SPSS, Inc, Chicago, IL). The data have been summarized as the mean ± standard deviation for continuous variables and as percentages for categorical data. Nominal data are reported as the number of subjects. Univariate (using the Fisher exact test) and multivariable analysis (using logistic regression test) was used to identify independent risk factors that lead to acute renal failure. The results of the logistic regression analysis were presented as odds ratio (OR) and 95% confidence intervals (CIs). Statistically significant differences were noted for each analysis, with statistical significance based on a P-value of < 0.05.

RESULTS

Ninety-eight patients with lower extremity arterial injury from August 2009 to March 2019 were included in this study. Of the patients, 66 males (67.3%) and 32 females (32.7%) were included. The number of patients over the age of 50 was 58 (59.2%). The mechanisms of injury were penetrating trauma (n=43, 43.9 %), blunt trauma (n=34, 34.7 %), and road traffic crash (n=21, 21.4%). The preoperative characteristics of patients are shown in Table-1.

Median duration of transportation to hospital was 4.1±1.2 hours (range 45 min to 9.30 h). The areas in which the patients lived were usually far away from the center (n=77, 78.6 %), and in most patients, vascular injury had resulted from occupational trauma (n=80, 81.6%).

The mean ISS was 14 (range, 11-42), and 11 patients (11.22 %) had ISSs of > 20 points. The mean MESS was 4.1 (range, 2-14), and 10 patients (10.20 %) had MESSs of > 7 points. The mean total ischemic time was 9.5 hours (range, 4-19 hours) (Table-2).

The diagnosis of vascular injuries had been established by physical examination (soft/hard signs), ankle brachial index and duplex ultrasound. When they were not diagnostic, arteriography was performed. Arteriography was performed in 28 cases (28.6 %). In 5 patients, arteriography was performed in the operating room, preoperatively.In terms of arterial injury location, the number of arterial injuries in the over the knee was greater than under the knee (most common femoral artery) Table-2 shows the details of the injured vessels. In addition to arterial injury, the number of simultaneous venous injuries, peripheral nerve damage, soft tissue, bone and muscle injuries are shown in Table-2.

In addition to arterial and venous revascularization, orthopedic fixation was performed in 10 patients and peripheral nerve repair was performed in 9 patients. Femoral and popliteal nerves had been injured in 3 and 2 cases, respectively. In addition, there was peroneal and tibial nerves damage in 4 patients. All associated nerve and tendon injuries had been repaired primarily.

The methods of vascular repair were primary closure, end-to-end anastomosis, graft interposition (saphenous vein and synthetic graft), lateral repair and ligation (Table-3). In large-scale vascular structures such as femoral and popliteal arteries, primary or end-to-end repair was performed if appropriate, but if there was a large vessel defect; graft interposition (saphenous vein or synthetic) was performed. Popliteal artery branches of the knee were frequently ligated. The tibial arteries under-knee were usually repaired by end-to-end anastomosis or saphenous vein interposition (e.g. femoro-tibialis bypass). The peroneal artery injuries were ligated, as were distal arterial and concomitant venous injuries. Intraluminal shunt was not used in any patient. Twelve patients (12.2 %) required fasciotomy in the intra-operative (n=5) and post-operative periods (n=7), successfully. These patients usually consisted of patients whose revascularization time exceeded 6 hours.

There was no per-operative death. Multi-organ failure was seen in 2 patients. These patients underwent late surgical revascularization and reconstruction (>12 h). Hemoglobin levels were lower than 7 mg/dL. More than 1000 cc of blood and blood product replacement was applied to these patients. In addition, hemodialysis was initiated after the second postoperative day. In addition, various degrees of lung complications were also present. These patients died on the 7th and 11th days. On the first postoperative day, a patient with large muscle and soft tissue damage died due to massive bleeding. The hospital mortality was seen in 6 patients. All of these patients had additional bone, nerve, and large tissue damage. Hemodialysis was performed due to renal injury in these patients. Table-4 demonstrates the details of the death cases.

In spite of arterial reconstruction, over-knee amputation was performed in 3 patients and under-knee in 4 patients. The causes of amputation were failed revascularization (1 patients), large soft tissue, bone and muscle defect (5 patient), and osteomyelitis (1 patients). Two patients had long-term wound and tissue infections. These patients underwent skin graft surgery by plastic surgery clinic. However, tissue healing was not sufficient in these patients, and a late under-knee amputation was performed.

Superficial wound site infections were seen in 21 patients. It was easily treated with simple debridement and antibiotics. Soft tissue infections were observed in 11 patients. Seven of these patients were treated with vacuum-assisted closure + antibiotics. In the other 4 patients, the wound sites were debrided, and soft tissues and skin were sutured and the wounds were closed after a few days of dressing. Renal functions were screened twice a day for all patients during intensive care unit period and once a day in cardiovascular surgery department. Renal injury findings (renal dysfunction) were seen in 24 patients (Table-5). Although creatinine levels increased in these patients, renal functions improved with fluid replacement therapy in 20 patients. The remaining 4 patients developed ARF. In addition to these 4 patients, ARF occurred in 10 patients. A total of 14 patients were followed up with ARF hematological and clinical findings. These patients who developed oliguria and anuria were followed up in intensive care unit. Hemodialysis was mandatory in 12 of these patients. Renal functions of these patients did not return to basic values, and hemodialysis program was continued in the early period after discharge. In 2 patients who developed ARF, renal injury improved with fluid treatment without hemodialysis.

The mean duration of stay in intensive care unit was 5.1±2.7 days, while total hospital stay was 16.7±3.1 days. The patients hospitalized in the intensive care unit for more than 3 days; patients with renal failure, hemorrhagic drainage from their drains, and pulmonary complications. In addition, the hospitalization period of these patients was longer. In addition to these results, some data are shown in Table-4.

In the logistic regression analysis, significant risk factors for the development of ARF were included: Age >50, ISS> 20, MESS> 7, blood and blood-product transfusion > 1000cc, volume loading with hydroxyethyl starch, hypotension on admission, hemodynamic shock, and intense soft tissue-muscle trauma (Table-5).

Table 1 The preoperative parameters and the patients' characteristics

Parameters	Patients (n)	%
Sex (M/F)	66/32	67.3/32.7
Age (mean, y)	42.2±7.1	
> 50	58	59.2
< 50	40	40.8
Smoker habits	51	52.0
Diabetes mellitus	32	32.7
Hypercholesterolemia	19	19.4
Chronic obstructive pulmonary disease	12	12.24
Volume loading with hydroxyethyl starch	58	59.2
Cerebro-vascular disease	8	8.2
Hypotension on admission		
70-90 mmHg	18	18.4
< 70 mmHg	4	4.1
Etiology		
Blunt injury	34	34.7
Penetrating injury	43	43.9
Road traffic crash injury	21	21.4
Clinic findings		
pulsatile bleeding	18	18.4
hematoma	74	75.5
ischemic findings (6P findings)	42	42.9
hemodynamic shock	4	4.1

Table 2 Details of the pathological tissues in the injured extremity and degree of injury according to trauma scores

Injured vessels	Patients (n)	%
Femoral artery	34	34.7
Popliteal artery	25	25.5
Tibial artery (anterior and posterior)	20	20.4
Peroneal artery	9	9.2
Dorsalis pedis artery	10	10.2
Additional femoral vein	15	15.3
Additional popliteal vein	10	10.2
Additional under-knee vein	20	20.4
Accompanying bone fracture	12	12.3
Intense soft tissue-muscle trauma	5	5.1
Peripheral nerve damage	9	9.2
Mangle extremity severity score (MESS)		
>7	10	10.2
Injury severity score (ISS)		
>20	11	11.2

Table 3 The operations and operative data

Parameters	Patients (n)	%
Operation time (hours)	4.2±2.8	
Intubation time (hours)	9.6±4.7	
Arterial repair		
Primary repair	11	11.2
Graft interposition	28	28.6
End-to-end anastomosis	14	14.3
Lateral repair	7	7.1
Ligation	38	38.8
Venous repair (n=45)		
Primary repair	2	2.0
Graft interposition	2	2.0
End-to-end anastomosis	11	11.2
Lateral repair	5	5.1
Ligation	25	25.5
Fasciotomy (due to compartment syndrome)	12	12.2

Table 4 Postoperative data related to patients

Parameters	Patients (n)	%
Duration of inotropic support (d)	4.1±3.1	
Vasoactive treatment	71	72.4
Blood and blood-product utilization (blood+fresh frozen plasma)		
< 500 cc	42	42.9
500-1000 cc	22	22.4
> 1000 cc	34	34.7
Volume loading with hydroxyethyl starch	66	67.3
Creatinine levels (mg/dL)		
< 1	44	44.9
1-1.5	30	30.6
1.5-1.8	9	9.2
1.8-2.0	8	8.1
> 2.0	7	7.1
Surgical revision for blood loss	18	18.4
Postoperative blood loss > 1000 mL	44	44.9
Acute renal failure	14	14.3
Postoperative hemodialysis	12	12.2
Permanent neurological dysfunction due to peripheral nerve damage (n=9)	2	2.1
Amputation		
over-knee	3	3.1
under-knee	4	4.1
late amputation	2	2.0
Multiorgan failure	2	2.0
Hospital mortality (within 30 d)	6	6.1
Operative mortality	0	0
Early mortality (48 h)	1	1.1
Pulmonary complications	9	9.2
Cerebral complications	1	1.1
Gastrointestinal complications	2	2.0
Infectious complications		
wound infection	21	21.4
soft tissue infection	11	11.2
Intensive care unit stay (d)	5.1±2.7	
Hospital stay (d)	16.7±3.1	

DISCUSSION

The lower extremity artery injuries are the most common type of vascular injury and constitute about one third of all cases. it is reported in the general population, as in our patients, mostly in young and male patients (70-90%). (1,8). Despite the improvements in diagnostic tools, surgical techniques, advances in emergency intervention and endovascular repair techniques, postoperative management, the limb salvage rate in lower extremity arterial injury may be difficult, at times. During the postoperative period a number of catastrophic scenarios may occur: amputation, reperfusion damage with a wide range of clinical presentations, and compartment syndrome etc. Prolonged preoperative period is a major reason for extremity losses. Besides, in these patients, complications such as amputation and organ insufficiency are still not uncommon according to the score of injury. In our study, the rate of amputation was found to be 9.2 % (9/98 patients), and a higher limb salvage rate was achieved according to some other studies (10-40%) (10-12). Our amputation rates were worse than some studies (8%) (13). In our study, there was no difference in terms of penetrating or blunt trauma for amputation reasons. However, amputations were more common in high-energy patients with high ISS and MESS scores, soft tissue, bone and muscle damage.

Despite successful revascularization of lower extremity arterial injury, severe reperfusion syndrome and compartment syndrome can be observed (12,14). Fasciotomy with an enhanced risk of infection and fluid loss may be beneficial against tissue gangrene or extremity loss. We had to perform 12 fasciotomies (12.24%) after successful revascularization for compartment syndrome in our patients. The overall fasciotomy rate in this study is similar to that in previously reported series (8,13). According to the degree of compartment syndrome, open or closed fasciotomies were performed to our patients. All fasciotomy wounds in our series were successfully closed using with primary closure or skin graft.

Table 5 Univariate and multivariate analyses of risk factors for the development of dialysis-requiring acute kidney failure

Variable	Univariate analysis		Multivariate analyses	
	OR (95% CI)	p value	OR (95% CI)	p value
Male gender	3.380 (1.691-6.188)	NS	3.621 (1.593-6.200)	NS
Age > 50	1.621 (1.109-4.009)	0.01	1.545 (1.029-4.114)	0.01
Hemodynamic shock	3.112 (1.760-6.670)	0.001	3.219 (1.877-6.770)	0.001
Hypotension on admission	1.498 (1.002-2.336)	0.001	1.498 (1.002-2.336)	0.001
Volume loading with hydroxyethyl starch	3.720 (2.155-6.198)	0.01	3.733 (2.401-6.367)	0.01
Smoker habits	2.478 (1.401-4.469)	NS	2.377 (1.568-4.655)	NS
Diabetes mellitus	2.388 (1.512-4.175)	NS	2.301 (1.555-4.093)	NS
Penetrating injury	0.711 (0.215-1.388)	NS	0.744 (0.331-1.489)	NS
Blunt injury	0.899 (0.589-1.711)	NS	0.910 (0.601-1.782)	NS
Vasoactive treatment	0.480 (0.105-1.099)	NS	0.377 (0.102-1.122)	NS
Orthopedic intervention	0.739 (0.544-1.892)	NS	0.810 (0.773-1.941)	NS
Additional venous injury	1.119 (0.340-3.270)	NS	1.209 (0.471-3.169)	NS
Ischemia >6h	1.498 (1.002-2.336)	NS	1.511 (0.945-2.122)	NS
MESS >7	2.161 (1.090-5.089)	0.001	2.593 (1.811-5.227)	0.001
ISS >20	2.121 (1.448-4.670)	0.002	2.208 (1.516-4.999)	0.004
Fasciotomy	1.251 (0.615-2.273)	NS	1.034 (0.488-1.932)	NS
Intense soft tissue-muscle trauma	1.411 (1.015-2.890)	0.01	1.345 (1.021-2.994)	0.001
Blood and blood-product transfusion > 1000cc	0.690 (0.441-1.811)	0.01	0.771 (0.501-1.955)	0.01
Surgical revision for bleeding	1.301 (0.940-3.155)	NS	1.388 (1.003-3.291)	NS
Operating time	2.670 (1.370-5.599)	NS	2.582 (1.269-5.402)	NS

OR: Odds ratio; CI: Confidence interval; ISS: Injury severity score;
MESS: Mangled extremity severity score; NS: Non-specific (p>0.05)

The length of hospital stay, need for intensive care unit admission, and mortality were significantly higher in patients presenting with acute renal failure than in those who did not present with renal injury (15-17). This result was consistent with our study. All of our patients who were hospitalized in our intensive care unit and in our clinic for more than 3 days were either patient who were lost or have gone into dialysis. These patients were easier to receive hemodialysis in the intensive care unit. In addition, the duration of hospitalization was prolonged due to the onset of lung complications (pneumonic infiltration, volume loading, blood transfusion reaction, and so on) in these patients. In addition, patients who had a broadly tissue defect in the tissues had a long operative time, and underwent orthopedic interventions because of bone defects. The duration of intensive care and hospitalization was longer.

Mortality rates vary in patients with major and critical trauma. In this study by Podoll *et al*., mortality rate was worse than our study. The 30-day mortality rate for the entire cohort was 83/901 (9.2%) (18). In another study, mortality rates were better than our study. In this study there were 172 deaths (4.0%) (16). Our findings confirm the significant increase in mortality in trauma patients that develop acute renal failure, an almost universal finding in the literature (5, 19-21). When the patients who died in our series were examined, almost all of our patients consisted of patients with large soft tissue, bone and muscle destruction traumas. In addition, in some of these patients, revascularization was delayed and a long time was spent to complete the tissue repairs. In these patients, acute renal failure due to renal damage developed in the early or postoperative days and they were taken into hemodialysis program.

Elderly, diabetes mellitus, serious shock or injury, high energy trauma and blood transfusion are known to increase the risk of kidney damage (1,20-22). In our study, we investigated the factors that might constitute a risk factor for ARF, and evaluated accompanied with different literature.

The rates of occurrence of renal failure associated with lower extremity trauma may show different rates. Rates ranging from 0.54% to 50% have been reported. The reason for this variability can be explained by the heterogeneity of the studied trauma population. For example; renal damage rates are higher in populations with established risk factors such as advanced age and high injury energy (1,23,24). Another reason for the variability in the reported incidence is the change in the time of diagnosis of renal injury. Some studies have accepted the post-operative first for 24 hours for post-operative renal failure, whereas in some studies, they have accepted the time after the first week. In our study, renal damage was evaluated after the first hours, postoperatively.

Postoperative ARF is a common risk among these patients with trauma. ARF is an acute decline in renal function with acute elevations in plasma BUN and serum creatinine. In ARF, an increase of serum creatinine occurs in a percentage of 50 which characterizes a severe reduction of urine output with oliguria less than 0.5 mL/kg/hr or anuria in a longer period than 6 hours with an increase in serum creatinine more than 0.5 mg/dL from the baseline. We have used KDIGO, the latest developed scoring system for acute renal failure criteria and hemodialysis indications. The causes of acute renal failure are conventionally reviewed into three groups: prerenal, renal, and postrenal. Severe hypovolemia (hypoperfusion secondary to haemorrhagic shock) and cardiac dysfunction are with prerenal ARF, and postrenal trauma of anatomic structures of urinary tract can be considered with a reason of postrenal ARF. Renal acute renal failure reasons are renal and relevant vascular trauma, massive blood and blood-product perfusions, perioperative nephrotoxic medications and myelonephropathic-metabolic syndrome (with myoglobin release). Among these scenarios, an acute tubular necrosis seems to be the most frequent reason for acute renal failure. Our patients generally appear to have renal failure due to prerenal and renal events. In these trauma patients, myelonephropathic-metabolic syndrome is a result of rhabdomyolysis and chain reactions of reperfusion. In a severe trauma situation toxic cellular content and free oxygen radical's leakage into the systemic circulation from muscle fibers and reperfused tissue result in several clinical consequences with a reduced renal function. Myelonephropathic-metabolic syndrome, hypovolemia, hyperkalemia, metabolic acidosis, dissemine intravascular coagulation may cause acute renal failure in a trauma patient.

One of the important risk factors for the development of acute renal failure is advanced age. In some studies, it has been suggested that trauma patients have a risk factor for the development of renal insufficiency above 50 years and some over 60 years (25-27). Although the mean age of our patients was younger, it was found to be a statistically significant risk factor in our patients over 50 years of age in terms of acute renal development. This result was found to be consistent with many previous studies.

Hypotension and hemodynamic shock are common in patients with trauma due to high volume and blood loss. In accordance with our study; many studies have shown that hypotension during hospitalization can cause acute renal failure even under 100 mmHg systolic dysfunction (25,28,29).

Transfusion of massive blood and blood products > 1000cc and volume loading with hydroxyethyl starch (HES) was found to increase renal damage in some studies in accordance with our studies in patients with trauma. The application of blood and blood products transfusion in the first 24-hour period due to hemodynamic disturbances has been shown to directly cause ARF (1,4,30,31). In our study, renal hypoperfusion caused by excessive transfusion of blood and HES in patients with hypotension and hemorrhagic shock caused acute renal failure and hemodialysis was required in 12 patients. However, based on the results of some study, volume resuscitation with HES or massive blood-blood products cannot be recommended in trauma patients. Or, careful use of these products is recommended (32,33).

In many studies; if trauma related tissue destruction is high due to extensive soft tissue, bone and muscle damage, the risk of developing renal failure is high in these patients (4,29,31). In these patients, renal damage may increase due to reasons such as excessive tissue destruction, acidosis, rhabdomyolysis, myelonephropathic-metabolic syndrome. In our cases, intense soft tissue-muscle trauma was found to be an independent risk factor for the development of renal insufficiency in patients with excessive tissue destruction.

MESS and ISS points are an important indicator in trauma patients. Values MESS> 7 are a strong indicator for amputation (34). However, it is seen that there is no study in terms of increasing renal damage in MESS score points. In our series, this high score points were found to be high risk for renal injury. In addition, in trauma patients a high ISS is a marker of severity and were independently associated with acute renal failure by logistic regression (28,35). These studies were consistent with our study.

CONCLUSION

Age >50, ISS> 20, MESS> 7, blood and blood-product transfusion > 1000cc, volume loading with hydroxyethyl starch, hypotension on admission, hemodynamic shock, and intense soft tissue-muscle trauma is powerful independent predictors of developing acute renal failure. Development of post-traumatic acute renal failure is closely associated with increased morbidity and mortality. In such cases, we were also careful to make maximum efforts to prevent renal damage. In our study, gender, smoker habits, diabetes mellitus, type of injury, vasoactive treatment, orthopedic intervention, add venous injury, fasciotomy, revisions, and operating time were not statistically significant associated with the incidence of acute renal failure.

Study Limitation

This study has several limitations. Firstly, this study was a single-center with a limited sample size. Therefore, we did not recommend any specific treatment method and indication of surgery. Second, as a single-center study, there may be bias due to case mix, quality of intensive care unit care, intensive care unit policy, and admission criteria. Third, data from our study have notable similarities and differences in the incidence, risk factor, and outcome of acute renal failure in comparison to other different parts of the world.

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Authors' Contributions

Bilgehan Erkut conceived and planned this work and wrote the manuscript with support from Azman Ates. Both authors collected and analyzed the data. Bilgehan Erkut helped supervise the findings of this work and assisted with data collection. All authors read and approved the final manuscript.

Conflict of Interest

We declare that there is no conflict of interest in our article

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No funding was received in this study.

Ethical Approval

This study was ethically approved by local ethics committee of Regional Training and Research Hospital Ethics Committee (date: March 01, 2019).

Consent

Written consent was provided by participants or their relatives.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

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