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Geriatric patients with known acute kidney injury and normal renal function at the time of admittance to the intensive care unit/assessment of RRT requirement and mortality: retrospective case-control study

Fatmanur Karakose · Muhammet Emin Akkoyunlu · Reha Erkoc · Abdullah Kansu · Mehmet Bayram · Murat Sezer · Hatice Ozcelik · Levent Kart

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Summary
Background The objective of our study was to investigate the renal functions on admittance, chronic disease status, the diagnosis on admittance to the intensive care unit (ICU), need for mechanical ventilation and medication groups and their impact over mortality and renal replacement treatment (RRT) requirement in geriatric patients with and without known acute kidney injury (AKI) at the time of admittance.

Methods A total of 168 patients over 65 years of age having been monitored for more than 24 h in our Respiratory ICU and were assessed retrospectively. Factors influencing the RRT requirement and the mortality rates of patients with known AKI and normal renal function at the time of admittance were reviewed.

Results Of 80 patients, 8 (10 %) without AKI at the time of admittance to the ICU required RRT during the follow-up, however, 72 of those (90 %) completed the follow-up without developing AKI. Of 88 patients, 29 (33 %) with AKI at the time of admittance to the ICU required RRT, however, 59 of those (67 %) completed the follow-up without any need for RRT.

Conclusions Presence of known AKI in the geriatric population at the time of their admittance to the respiratory ICU remarkably increased both the need for RRT and the mortality with respect to the geriatric population with normal renal functions. After having assessed the reasons justifying RRT and increasing the mortality during the intensive care, gastrointestinal bleeding and hypotension which necessitate the combined use of dopamine and noradrenaline were concluded to be prominent.

Keywords Acute kidney injury · Geriatric patients · Intensive care unit · Concomitant disease · Renal replacement therapy

Geriatrische Patienten mit bekanntem akuten Nierenversagen und normaler Nierenfunktion zum Zeitpunkt der Aufnahme an der Intensivstation. Erfassung der Notwendigkeit einer Nierenersatztherapie und der Mortalität: eine retrospektive Case-Control Studie

Zusammenfassung
Grundlagen Ziel dieser Studie war es, folgende Parameter bei geriatrischen Patienten mit und ohne bekanntem akuten Nierenversagen (ANV) zum Zeitpunkt der Aufnahme an der Intensivstation zu untersuchen: die Nierenfunktion bei Aufnahme, ob chronische Erkrankungen vorliegen, Diagnose bei Aufnahme an der Intensivstation, Notwendigkeit einer mechanischen Beatmung, die Medikation und ihre Bedeutung für die Mortalität, sowie die Notwendigkeit einer Nierenersatztherapie.

Methodik Es wurden 168 Patienten, die älter als 65 Jahre alt waren, und die mehr als 24 h an unserer Intensivstation überwacht wurden, retrospektiv analysiert. Faktoren, die den Einsatz einer Nierenersatztherapie beeinflussten, und die Mortalitätsraten wurden

F. Karakose, MD (✉) · M. E. Akkoyunlu · A. Kansu · M. Bayram · M. Sezer · H. Ozcelik · L. Kart
Department of Chest Disease, Bezmialem Vakif University Medical School,
Istanbul, Turkey
e-mail: fatmanurkarakose@yahoo.com;
fkarakose@bezmialem.edu.tr

F. Karakose, MD
Rifat Ilgaz Bulvari, Cevat Dursunoglu sok,
3-4 Kisim 0-134 Daire 7, Atakoy,
34158 Bakirkoy/Istanbul, Turkey

R. Erkoc
Department of Nephrology, Bezmialem Vakif University Medical School,
Istanbul, Turkey

bei Patienten mit bekanntem ANV und solchen mit normaler Nierenfunktion bei Aufnahme erhoben.

Ergebnisse Acht von 80 Patienten (10 %) ohne ANV bei Aufnahme an der Intensivstation benötigten während der Beobachtungsperiode eine Nierenersatztherapie. Dahingegen trat bei den restlichen 72 Patienten bis zum Ende der Beobachtung kein ANV ein. 29 von 88 Patienten (33 %) mit ANV zum Zeitpunkt der Aufnahme an der Intensivstation benötigten eine Nierenersatztherapie, bei den restlichen 59 (67 %) trat bis zum Schluss der Beobachtung kein ANV ein.

Schlussfolgerungen In der untersuchten geriatrischen Population führte das Vorhandensein eines ANV zum Zeitpunkt der Aufnahme an die Intensivstation sowohl zu einem Anstieg der Notwendigkeit einer Nierenersatztherapie als auch der Mortalität im Vergleich zu den geriatrischen Patienten mit normaler Nierenfunktion bei Aufnahme. Nach Durchsicht der Gründe, die die Nierenersatztherapie notwendig machten, sowie der Todesursachen während des Aufenthaltes an der Intensivstation stellten sich Blutungen im Gastrointestinaltrakt und katecholamin-abhängiger Blutdruckabfall als wesentliche Faktoren dar.

Schlüsselwörter Akutes Nierenversagen · Geriatrische Patienten · Intensivstation · Therapie von begleiterkrankungen · Nierenersatz

Introduction

Acute kidney injury (AKI) is defined as spontaneous, persistent, and theoretically considered reversible worsening of the renal functions with an increase in urea and serum creatinine (sCr) values, and a decrease in diuresis. AKI is a potentially treatable disease. Early diagnosis has a positive impact on the outcomes of the treatment [1].

AKI may develop in the absence of an acute or chronic kidney disease. The risk factors which might cause AKI are the concomitant diseases [chronic obstructive pulmonary disease; diabetes mellitus (DM); hypertension (HT); heart failure (HF); atrial fibrillation], cirrhosis, sepsis, prostatic hypertrophy, malignity, nephritis. Predisposing factors are accepted as hypovolemia, sepsis, infection, medications, major surgery, and multisystem organ failure [1–4].

The incidence of development in the hospital is 1.5–3.5 times greater than the incidence of development in the community [2]. The incidence in the intensive care unit (ICU) for all age groups, and the mortality rate depending on the type of the disease, need for renal replacement treatment (RRT) and multiple organ failure was reported to be 20–40 % and 40–80 %, respectively.

The mortality rate in the geriatric population with comorbid diseases was reported to be 39–80 % [5–7].

The number of elderly patients followed in hospitals or ICUs is increasing due to evolving conditions of life and prolonged life expectancy. Expected life-time in Europe is 76.1 years for men and 82.2 years for women. As the frequency of hospital admissions increase in the geriatric population, the prevalence of AKI in the hospitalized patients are also observed to increase. Renal reserve has been decreased in the elderly due to the decrease in nephrons, anatomical/functional alterations and other possible diseases (HT, diabetes, atherosclerosis, HF, ischemic renal diseases, and obstructive uropathy). For this reason, development of AKI at advanced ages is much easier than at younger ages and AKI is seen more often especially in hospitalized patients [8].

Especially cardiovascular surgery patients monitored in the ICU and patients using a contrast agent, as well as those with a prominent respiratory failure are reported in epidemiological studies to be under additional risks [9]. Advanced age has been defined as an independent risk factor for the development of AKI [10].

AKI treatment usually does not vary between the younger and elder groups of patients, however, the required therapy is generally RRT in critical patients [2, 7]. Respiratory and cardiovascular diseases, surgical interventions and sepsis are the most significant clinical conditions which increase mortality together with AKI. Early diagnosis of AKI has a positive impact on the outcomes of the treatment. For this reason early recognition of the factors which predispose the development of AKI is important, as well as identifying the potential risks of AKI to take fast protective measures is of great importance during clinical follow-up [8, 11, 12].

The factors influencing the mortality rates and RRT requirement of the geriatric patients with known AKI at the time of admittance to the respiratory ICU were reviewed in our study in comparison with those normal renal function on admittance. In both groups, diagnosis for admittance to the ICU, chronic disease status, duration of hospitalization, the need for mechanical ventilation (MV), medication groups and their impact on mortality and RRT requirements were investigated.

Patients, materials, and methods

Patients over 65 years of age, who have been followed-up in our Respiratory ICU, were scanned retrospectively between September 2010 and June 2012 through the automation system with the approval of the Local Ethics Committee. Primary outcome was defined as the need for RRT and the secondary outcome was defined as the mortality, and the patients with known AKI at the time of admittance (case) were compared with the geriatric patients with normal renal functions (control).

Depending on the hypothesis that the need for RRT and the mortality rates are higher in patients with known AKI, diagnosis at the time of admittance to the ICU, chronic disease status, duration of hospitalization, need for mechanical ventilator and the effects of drug groups were investigated in both groups.

The effects of the below defined parameters on primary and secondary endpoints (the need for RRT and mortality, respectively) were analyzed by the univariate and multivariate regression methods.

Table 1 Modified scale of chronic disease

1. *Cardiovascular*: NYHA Class 4, Angina or symptoms developing during rest or with minimal effort
2. *Hepatic*: Cirrhosis confirmed by a biopsy, portal hypertension, previous variceal bleeding, hepatic failure, encephalopathy
3. *Respiratory*: Obstructive, restrictive or vascular diseases causing incapacity in severe exercise (stairs inability or chronic hypoxemia, pulmonary hypertension > 40 mmHg, presence of secondary polycythemia
4. *Immunocompromised patients*: Immunosuppressive treatment, chemotherapy, radiotherapy, until 30 days before admittance to the ICU long-term low dose or short-term (5 days or longer) high dose (> 15 mg/kg) steroid use, leukemia, lymphoma, AIDS, metastatic cancer
5. Patients under chronic hemodialysis or peritoneal dialysis, patients being followed-up due to CRF
6. Diabetes mellitus
NYHA New York Heart Association, *ICU* intensive care unit, *AIDS* acquired immune deficiency syndrome, *CRF* chronic renal failure

1. Diagnosis for admission to the ICU [acute respiratory failure (ARF), coma, shock [septic, cardiogenic, hemorrhagic], gastrointestinal (GIS) bleeding, neurological disease]
2. Other known diseases at the time of admittance to the ICU (modifying the Scale of Chronic Health Condition, Table 1) [12]
3. MV requirement
4. Medications used during the hospitalization in the ICU (antibiotics, angiotensin-converting enzyme inhibitors, nonsteroidal anti-inflammatory drugs, dopamine, noradrenaline, or dopamine/noradrenaline combination, contrast agent)

The records of 184 patients over 65 years of age were retrieved within the defined timeframe. Of those, 16 were excluded (exitus or discharged) as their follow-up lasted shorter than 24 h, and the remaining 168 patients were included into assessments (Fig. 1).

Demographic data of the patients, as well as the clinical and biochemical parameters (basal urea and sCr values, hourly urine output, duration of hospitalization, MV requirement, mean duration of intubation) are shown in Table 2.

Acute Kidney Injury Network Criteria were used to define AKI [8, 11, 12]. High level of creatinine was considered as the criterion for the patients, whose creatinine values on admittance to the ICU were detected to be high. No previous creatinine values were available for these patients. The patients, whose values dropped down to the normal limits with an optimal hydration within 24 h of admission to the ICU, were assessed in the control group.

AKI was defined according to the below criteria:

- An increase in sCr 0.3 mg/dl within 48 h, or
- Increase in sCr ≥ 1.5 times baseline, which is known or presumed to have occurred within the prior 7 days.
- Urine volume < 0. 5 ml/kg/h for 6 h.

Statistical assessments were made by utilizing the software SPSS Version 16. Parameters were assessed by the

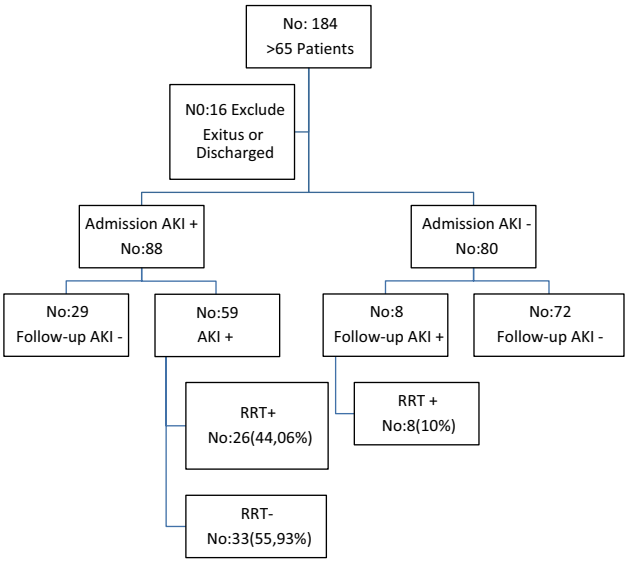

Fig. 1 Study design

t-test, Pearson's χ^2 test and uni/multiregression analyses (Tables 3, 4, 5, 6).

Findings

The records obtained belongs to 184 patients who were over 65 years of age, and were followed-up in the Respiratory ICU between September 2010 and June 2012 of those were excluded (exitus or discharged), as their monitoring lasted shorter than 24 h, and 168 patients were included into our assessments (Fig. 1). The demographic data, biochemistry and clinical findings of the patients are denoted in Table 2.

When patients with (case) and without (control) known AKI at the time of admittance to the ICU were assessed, no significant differences were detected between the two groups with respect to age, gender, average duration of hospitalization, need for invasive/noninvasive MV and intubation period, and how many days after the admittance the RRT was done.

In both groups, known chronic disease status revealed by the *Scale of Modified Chronic Health Condition* at the time of admittance to the ICU, dispersion and rates are given in Table 2. When assessed with respect to the existing chronic diseases, the detection of AKI on admittance was statistically significant only in patients with cardiovascular system disorders ($p < 0.05$).

Of 80 patients, 8 (10 %) without AKI at the time of admittance to the ICU required RRT during the follow-up, however, 72 of those (90 %) completed the follow-up without developing AKI. Of 88 patients, 29 (32.95 %) with known AKI at the time of admittance to the ICU, renal function impairment was resolved with treatment. Of the remaining 59 patients, 26 (44.6 %) with known AKI at the time of admittance to the ICU required RRT, however, 33 of those (55.93 %) completed the follow-up without any need for RRT (Fig. 1). The rate of RRT implementation

Table 2 Patients with/without known AKI at the time of admittance to the ICU

	Without AKI at the time of admittance No. 80	With AKI at the time of admittance No. 88
Average age	76.34 (±8.12)	73.99 (±10.19)
Gender	K:41 (%55.4) E:39 (%41.5)	K:33 (%44.6) E: 55 (%58.5)
Average duration of hospitalization	9.78 (±9.05) 80 hasta	10.44 (±12.88) 88 hasta
Mechanical ventilation	54/80 (67.5%)	67/88 (%76.1)
NIMV	26/80 (32.5%)	21/88 (23.9%)
Average intubation period (days)	10.24 (±9.87) No: 54	8.53 (±10.42) No: 70
BUN (mg/dl)	27.65 (±13.01)	58.20 (±31.58) No: 88
SCr (mg/dl)	0.83 (±0.22)	2.38 (±1.68) No: 88
Urine (ml/h), 168 patients	70.75 (±45.31)*	49.77 (±52.04)*
Diagnosis for hospitalization (=1)	43 (53.8%)	16 (18.2%)
Diagnosis for hospitalization (≥2)	37 (46.2%)	72 (81.8%)**
Ex	29/80 (%36.2)	50/80 (%56.8)*
Discharged	51/80 (%63.8)*	38/88 (%43.2)
RRT		
RRT days, 34 patients	11.38 (±9.21)	6.27 (±9.26)
RRT implemented	8 (%10)	26 (%29.5)*
RRT not implemented	72 (%90)*	62 (%70.45)
Chronic disease status		
Cardiovascular system	32 (%40)	53 (%60.2)*
Hepatic diseases	3 (%3.8)	10 (%11.4)
Respiratory diseases	73 (%91.2)**	59 (%67)
Immunocompromised patients	13 (%16.2)	15 (%17)
Chronic renal failure/(RRT)	–	35 (%39.8) RRT:3
Diabetes mellitus	9 (%11.2)	18 (%20.5)
Chronic disease (single)	37 (46.2%)	33 (37.5%)
Chronic disease (≥2)	43 (53.8%)	55 (52.5%)

AKI acute kidney injury, *ICU* intensive care unit, *NIMV* noninvasive mechanical ventilation, *BUN* blood urea nitrogen, *sCR* serum creatinine, *RRT* renal replacement treatment
[a]Three patients chronic renal failure, under dialysis
*$p<0.05$; **$p<0.001$

Table 3 Univariate logistic regression of RRT necessary

	ODDs, 95% CI	*p*
Gender, male	1.57 (0.72–3.44)	0.252
Average duration of hospitalization	1.02 (0.98–1.05)	0.20
Mechanical ventilation	8.09 (1.85–35.28)	*<0.001*
Known AKI at the time of admittance	3.77 (1.59–8.93)	*0.003*
Known and persistence AKI at the time of hospitalization	7.37 (3.07–17.65)	*<0.001*
Primary diagnosis for hospitalization		
Diagnosis of acute respiratory failure	0.5 (0.44–5.68)	0.57
Post cardiac arrest	1.11 (0.38–3.24)	0.84
Shock (septic, cardiogenic, hemorrhagic)	2.45 (1.09–5.51)	0.03
Neurological disease	0.77 (0.29–2.05)	0.6
GIS bleeding	22.6 (6.5–78.2)	*<0.001*
Total diagnoses for hospitalization ≥2	25.18 (3.34–189)	*0.002*
Chronic diseases		
CVS	1.12 (0.52–2.39)	0.75
Hepatic diseases	1.85 (0.53–6.42)	0.33
Respiratory disease	0.40 (0.17–0.91)	0.31
Immunocompromised patients	1.39 (0.53–3.61)	0.49
Diabetes mellitus	0.64 (0.20–2)	0.44
Chronic disease ≥2	0.88 (0.41–1.88)	0.74
Treatments		
Antibiotic	3.24 (0.40–25.8)	0.26
Dopamine	2.14 (0.96–4.78)	0.062
Dopa/noradrenaline combination	2.90 (1.29–6.51)	*0.009*

RRT renal replacement treatment, *AKI* acute kidney injury, *GIS* gastrointestinal, *CVS* cardiovascular

Table 4 Multivariate logistic regression of RRT necessary

AKI persistence at ICU follow-ups	1.65 (0.51–5.25)	0.39
ICU known AKI at the time of admittance	1.07 (0.34–3.37)	0.90
MV requirement	4.42 (0.87–22.22)	0.71
ICU diagnosis for hospitalization GIS bleeding	8.29 (1.76–38.9)	*0.007*
ICU diagnosis for hospitalization shock	1.16 (0.41–3.30)	0.77
Dopa/noradrenaline combination	1.00 (0.39–3.05)	0.86
diagnosis for hospitalization ≥2	3.39 (0.31–37.12)	0.31

RRT renal replacement treatment, *AKI* acute kidney injury, *ICU* intensive care unit, *MV* mechanical ventilation, *GIS* gastrointestinal

was found to be statistically significant during the follow-up of the patients with AKI at the time of admittance to the ICU (Table 2) ($p<0.05$).

The number of patients receiving RRT during their follow-up period in the ICU was 34. Three of those with chronic kidney disease were scheduled for RRT, and the dialysis of these patients continued during their intensive care. In all, 31 patients were decided to receive RRT during their follow-up in the ICU.

The impact of the following over the primary and secondary endpoints (need for RRT and mortality, respectively) were analyzed by the univariate and multivariate regression methods:

Gender, duration of hospitalization, MV requirement, presence of AKI on admittance, diagnosis for admittance to the ICU, other known diseases on admittance to the ICU (Scale of Modified Chronic Health Condition, Table 1) and medications used during the intensive care (Tables 3–6).

When the primary endpoint was taken as RRT, the need for MV and persistence of AKI during hospitalization, shock, GIS bleeding, more than two diagnoses for hospitalization, combined use of dopamine/noradrena-

Table 5 Univariate logistic regression of mortality

	ODDs, 95 % CI	*P*
Gender, male	0.84 (0.45–1.54)	0.57
Mechanical ventilation	0.057 (0.019–0.169)	*0.57*
Known AKI at the time of admittance	0.43 (0.23–0.80)	*0.008*
Known and persistence AKI at the time of hospitalization	0.30 (0.16–0.58)	*< 0.001*
Primary diagnosis for hospitalization		
Diagnosis of acute respiratory failure	1.17 (0.86–1.59)	0.31
Post cardiac arrest	0.52 (0.21–1.28)	0.15
Shock (septic, cardiogenic, hemorrhagic)	0.24 (0.11–0.53)	*< 0.001*
Neurological disease	0.80 (0.38–1.68)	*0.55*
GIS bleeding	0.18 (0.09–0.35)	*< 0.001*
Total diagnoses for hospitalization ≥ 2	0.24 (0.11–0.48)	*< 0.001*
Chronic diseases		
CVS	1.12 (0.52–2.39)	0.75
Hepatic diseases	1.85 (0.53–6.42)	0.33
Respiratory disease	0.40 (0.17–0.91)	0.31
Immunocompromised patients	1.39 (0.53–3.61)	0.49
Diabetes mellitus	0.64 (0.20–2)	0.44
Concomitant disease ≥ 2	1.33 (0.71–2.47)	0.36
Treatments		
Antibiotic	3.24 (0.40–25.8)	0.26
Dopamine	2.14 (0.96–4.78)	0.062
Dopa/noradrenaline combination	2.90 (1.29–6.51)	*0.009*

AKI acute kidney injury, *GIS* gastrointestinal, *CVS* cardiovascular

Table 6 Multivariate logistic regression of mortality

	ODDs, 95 % CI	*P*
AKI persistence at ICU follow-ups	1.38 (0.38–3.36)	0.81
Known AKI at the time of admittance to ICU	10.76 (0.29–1.97)	0.57
ICU diagnosis for hospitalization GIS bleeding	0.31 (0.09–1.01)	*0.52*
ICU diagnosis for hospitalization shock	0.65 (0.21–1.98)	0.45
Dopa/noradrenaline combination	0.01 (0.02–0.11)	*< 0.001*
Diagnosis for hospitalization ≥ 2	0.64 (0.20–2.06)	0.45

AKI acute kidney injury, *ICU* intensive care unit, *GIS* gastrointestinal

line were significant when assessed by the univariate regression analysis, however, patients with a diagnosis of GIS bleeding only at the time of hospitalization were found to be significant by the multivariate regression analysis with an ODDs ratio of (95 % CI) 8.29 (1.76–38.9) (95 % CI) $p = 0.007$.

When the secondary endpoint was taken as the mortality, AKI persistence at hospitalization, shock, GIS bleeding, more than two diagnosis for hospitalization, combined use of dopamine and noradrenaline were significant by the univariate regression analysis, however, only the combined use of dopamine and noradrenaline was found to be significant by the multivariate regression analysis with an ODDs ratio of 0.01 (0.02–0.11) (95 % CI) $p < 0.001$.

Discussion

Presence of known AKI at the time of admittance in the geriatric patients monitored in the respiratory ICU significantly increases the need for RRT and the mortality with respect to the population with normal renal functions ($p < 0.05$) (Table 1). GIS bleeding and hypotension necessitating the combined use of dopamine/noradrenaline were prominent, when the reasons for predisposing the need for RRT during the intensive care and the increase in mortality were examined. The need for RRT increases in geriatric patients who had GIS bleedings during their intensive care (ODDs, 8.29 (1.76–38.9) ($p < 0.007$)). There was a significant increase of risk in the univariate analysis in terms of mortality, however, no significance was detected in the multivariate analysis. Combined use of dopamine/noaradrenalin increases the risk both in terms of RRT (ODDs, 1 (0.39–3.05)) and in terms of mortality (ODDs, 0.01 (0.02–0.11)) (Tables 3–6).

As the data were obtained retrospectively by scanning the automation system, the lack of information about the course of arterial blood pressure as well as the lack of information about the APACHE II score are the main limitations of the study. AKI staging of the patients were not mentioned in the study, as this could not be done precisely on a retrospective basis. Likewise, with respect to the medications used, no sub-group segregation has been made for antibiotics. Patients using a contrast agent were excluded from consideration as they were very few in number. However, we are in the opinion that the strengths of this study are the high enrollment rate, and the specifically targeted population of geriatric patients.

AKI in the ICU has an incidence between 20 and 60 % and it is a common problem, as the mortality varies between 40 and 90 % depending on comorbid diseases. It was considered as an independent parameter in terms of mortality [5]. The incidence of AKI and the mortality rate in the nongeriatric population monitored in the ICU are determined in the medical literature as 7–17 and 23–34 %, respectively [4, 7]. The global mortality for the geriatric patients with AKI, who are followed in the ICU, was given in different studies as 42–61 % [7]. In our study, 88 of 168 geriatric patients (52.38 %) followed in the ICU had known AKI at the time of admittance and the mortality was 56.8 % in this group. The mortality was 36.2 % in patients without known AKI at the time of admittance (80/168). Current mortality rates were consistent with the literature [2, 7, 8, 11].

When assessed on the basis of the present chronic diseases according to the Scale of Modified Chronic Health Condition, the detection of AKI at the time of admittance to the ICU was statistically significant only in patients with a cardiovascular system disease ($p < 0.05$). Cardiovascular diseases are the known risk factors for AKI [8]. However, no correlation was detected in our study between the presence of other comorbidities and the known AKI at the time of admission. For patients with comorbidities (such as cardiovascular disease, hepatic disease, respiratory disease, immune suppression, DM,

and single or ≥2 diseases), no significant association in terms of the need for RRT, or in terms of mortality could be detected by the univariate and multivariate regression analyses during the follow-up phase (Tables 3, 5).

The data are variable about the need for RRT in ICU, but geriatric patients are known to be more prone to develop AKI. In one of the studies of Lima et al., RRT requirement emerged in the 33, and 36 % of the total population of 829 patients for the early AKI and delayed AKI, respectively [6]. Contrary to the expectations, the rate of RRT for the elderly patients, for the young patients and for the whole group was found to be 12, 24, and 36 %, respectively in a study of Gong et al. [7]. RRT was implemented in the 11.7 % of 171 geriatric patients in a study of Sahin et al. [13]. In our study, 8 of 80 patients (10 %) without known AKI at the time of admittance required RRT during the follow-up, however, 72 of those (90 %) completed the follow-up without developing AKI. RRT was required for 26 of 59 patients (44.6 %) with known AKI at the time of admittance, and 33 patients (55.93 %) were followed-up without any need for RRT. The implementation rate of RRT was found to be statistically significant during the follow-up of the patients who were detected to have AKI at the time of admittance to the ICU (Table 2) ($p<0.05$). When the primary endpoint was taken as RRT, the need for MV and persistence of AKI during hospitalization, shock, GIS bleeding, more than two diagnoses for hospitalization, combined use of dopamine/noradrenaline were significant when assessed by the univariate regression analysis, however, patients with a diagnosis of GIS bleeding only at the time of hospitalization were found to be significant by the multivariate regression analysis with an ODDs ratio of 8.29 (1.76–38.9) (95 % CI) $p=0.007$.

Development of AKI in the ICU may be of different causes. Another organ failure (post-cardiogenic shock) may cause AKI, as well as AKI may cause secondary organ injuries as a primary pathology (AKI-related oliguria and respiratory failure due to fluid overload). Apart from these, any disease like sepsis and vasculitis causing multiorgan failure may lead to AKI [5].

When geriatric patients were assessed in terms of the relation between the diagnosis for the ICU admittance and AKI, 165 of our 168 patients (98.2 %) had acute respiratory failure as a concomitant disease or as a single diagnosis (no data shown). According to one of the studies of Osterman et al., acute respiratory failure is the most common disease that accompanies to AKI and it was assessed to be in association with the high mortality rates of the Syndrome of Combine Acute Renal And Respiratory Failure Syndrome [5]. However, no significant relationship was detected in our study between the acute respiratory failure diagnosis and the need for RRT (ODDS ratio 0.5 (0.44–5.68) (90 % CI) $p=0.31$) (Table 3). Likewise no significant relation was detected between RRT requirement and cardiac arrest, shock, neurological disease diagnoses. GIS bleeding (ODDS ratio 22.6 (6.5–78.2), $p<0.001$), and more than two diagnoses for hospitalization (ODDS ratio 25.18 (3.34–189) (90 % CI), $p=0.002$) were found to be significant in the univariate analysis (Table 3).

When the secondary endpoint was taken as the mortality, AKI ongoing at hospitalization, shock, GIS bleeding, more than two diagnosis for hospitalization, and the use of dopamine/noradrenaline in combination were found to be significant by the univariate regression analysis, however, the ODDs ratio was found to be (95 % CI) 0.01 (0.02–0.11) by the multivariate regression analysis in patients for whom only dopamine/noradrenaline was used in combination ($p<0.001$) (Table 6).

More than two diagnoses for hospitalization, hypotension requiring the combined use of dopamine noradrenaline, GIS bleeding were the factors increasing the risk of mortality in our study. The condition decreasing renal perfusion was the need for RRT at the ICU as expected, and these were the most significant clinical conditions increasing the mortality.

For the development of AKI, the sensitivity of the geriatric patients to hypotension and to the conditions reducing renal perfusion are known to be higher than the younger population. AKI is a reversible clinical condition and early diagnosis may improve outcomes. There is certainly an unmet need for studies determining the parameters which would help the early diagnosis of AKI in patients hospitalized at ICUs.

Conflict of interest

The authors declared that there is no conflict of interests.

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