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# Outcome in noncritically ill patients with acute kidney injury requiring dialysis
## Effects of differing medical staffs and organizations

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## Abstract

Acute kidney injury requiring dialysis (AKI-D) treatment has significantly increased in incidence over the years, with more than 400 new cases per million population/y, 2/3 of which concern noncritically ill patients. In these patients, there are little data on mortality or on information of care organization and its impact on outcome. Specialty training and integrated teams, as well as a high volume of activity, seem to be linked to better hospital outcome. The study investigates mortality of patients admitted to and in-care of nephrology (NEPHROpts), a closed-staff organization, and to other medical wards (MEDpts), representing a model of open-staff organization.

This is a single center, case–control cohort study derived from a prospective epidemiology investigation on patients with AKI-D admitted to or in-care of the Hospital of Perugia during the period 2007 to 2014. Noncritically ill AKI-D patients were analyzed: inclusion and exclusion criteria were defined to avoid possible bias on the cause of hospital admittance and comorbidities, and a propensity score (PS) matching was performed.

Six hundred fifty-four noncritically ill patients were observed and 296 fulfilled inclusion/exclusion criteria. PS matching resulted in 2 groups: 100 NEPHROpts and 100 MEDpts. Characteristics, comorbidities, acute kidney injury causes, risk–injury–failure acute kidney injury criteria, and simplified acute physiology score (SAPS 2) were similar. Mortality was 36%, and a difference was reported between NEPHROpts and MEDpts (20% vs 52%, $\chi^2 = 23.2$, $P < 0.001$). Patients who died differed in age, serum creatinine, blood urea nitrogen/s.Creatinine ratio, dialysis urea reduction rate (URR), SAPS 2 and Charlson score; they presented a higher rate of heart disease, and a larger proportion required noradrenaline/dopamine for shock. After correction for mortality risk factors, multivariate Cox analysis revealed that site of treatment (medical vs nephrology wards) represents an independent risk factor of mortality (relative risk = 2.13, 95% confidence interval = 1.25, 3.63; $P < 0.01$). Other independent risk factors were age, URR, s.Creatinine at hemodialysis beginning, and SAPS 2 score.

In our context, we have documented that noncritically ill AKI-D patients, who represented 2/3 of the population, had high in-hospital mortality (36%), and that a closed-staff specialty medical organization, such as a Nephrology team, seems to guarantee a better outcome than general medical organizations. The significance in healthcare system organization and resource allocation could be important.

**Abbreviations:** AKI = acute kidney injury, AKI-D = acute kidney injury requiring dialysis, BUN = blood urea nitrogen, CKD = chronic kidney disease, HD = hemodialysis, HDf = hemodiafiltration, ICU = intensive care unit, MEDpts = patients admitted to and in-care of medicine wards, NEPHROpts = patients admitted to and in-care of nephrology, PS = propensity score, RIFLE = risk of renal injury/injury to the kidney/failure of kidney function/loss of kidney function/end stage kidney disease, ROC = receiver operating characteristic, RRT = renal replacement therapy, SAPS 2 = simplified acute physiology score, SLED-f = sustained low-efficiency hemodiafiltration, SOFA = sequential organ failure assessment, URR = urea reduction rate.

**Keywords:** acute kidney injury, noncritically ill patients, organization, survival

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## 1. Introduction

Despite abundant information about hospital-based acute kidney injury (AKI) in intensive care units (ICUs), which reveals a continuous increase of cases over the years and a high mortality,[1,2] few data are present for noncritically ill patients. Reports in acute medical admissions point out some concepts important to the organization of a healthcare system with a focus on tertiary-care hospitals: those with on-site specialty consultants seem to provide better outcomes while a delay in nephrologist intervention can result in a higher mortality or hospital readmission. Other aspects need to be investigated, such as the oscillation of in-hospital mortality, which can range in the case of ICU patients from 45% to 80%. Moreover, a large proportion of patients need to continue dialysis after hospital discharge, and those patients who remain free from dialysis have a high risk of mortality and morbidity in the subsequent years.[3–8]

The aim of our study was to assess whether in acute kidney injury requiring dialysis (AKI-D) patients the medical organization and team specialization are associated with different outcomes. The study hypothesis to investigate was that mortality of patients admitted to and in-care of nephrology (NEPHROpts) department, a closed-staff organization, could be lower in comparison with other medical wards.

## 2. Methods

### 2.1. Study design

This is a propensity score (PS) matched 1:1 case–control cohort study derived from a prospective epidemiology investigation conducted from 2007 to 2014 in a Regional University Hospital in Italy. Initially, all cases of AKI-D were recorded. Thereafter, we have comparatively analyzed NEPHROpts department and other medical wards. We had previously designed a questionnaire to analyze several aspects, as elsewhere explained.[9] The study was initiated on January 1, 2007 and terminated on December 31, 2014 to avoid bias. The following outcomes were analyzed: in-hospital mortality and need to continue dialysis at the time of hospital discharge. This retrospective case–control cohort investigation is in compliance with the Declaration of Helsinki. We have collected completely anonymous data extracted from hospital records, and consequently an informed consent was not required.

### 2.2. Hospital setting

The University Hospital of Perugia has 850 beds and serves a population of 354,000 inhabitants. A 24-hour nephrology and dialysis service is present in hospital. AKI patients not requiring ICU have been admitted if possible to the Nephrology Department, which has a dedicated team, or otherwise to other Medical Departments. Nephrology has a ward with 12 beds, with a section dedicated to acute kidney injury (AKI), where patients can be dialyzed and their cardiovascular condition can be monitored. Two consultants and 2 or 3 medical doctors in specialty training are directly involved in Clinical Nephrology and AKI. A total of 10 medical doctors are present in the Nephrology Department. In the cases of other Medical Departments, the number of medical wards analyzed is 11, with a total of 139 medical doctors and 272 beds. In this case, a specialist kidney consultation was performed before dialysis treatment, and nephrology technicians have executed dialysis. Consultations to medical wards were performed by all the nephrologists of the department, whether or not they were directly involved in AKI or in other subspecialties. Consulting to medical wards was an open-staff model organization, in the sense that the same patient received consultation during in-hospital stay from the Nephrologist present at the moment of request. A report of Perugia Hospital workload and clinical activities is published elsewhere.[10]

### 2.3. Inclusion and exclusion criteria

Patients with AKI-D, aged 20 to 85 years, were studied. The classification of AKI was made according to risk–injury–failure acute kidney injury criteria (RIFLE) score.

Patients in-care to surgery wards, or admitted for a period to ICU, were not considered. To avoid possible bias concerning the cause of admittance, the criteria of exclusion were surgical causes, obstructive kidney disease, solid or hematology malignancies,

end-stage renal disease awaiting the beginning of dialysis treatment.

### 2.4. Treatment methods

Dialysis treatments were prescribed in accordance with internal procedures, as reported elsewhere.[9] Hemodialysis (HD) was customized on the basis of treatment length and efficiency. Treatments of patients were performed in the acute dialysis section of nephrology ward, except for those who could not be transported. Anticoagulation for renal replacement therapy (RRT) was performed with citrate in case of bleeding or to reduce the risk of it, otherwise with unfractionated or low molecular weight heparin.

### 2.5. Types of treatments

(1) *Sustained low-efficiency hemodiafiltration (SLED-f)*: performed with Prismaflex monitor (Gambro, GAMBRO-BAXTER Italia, Mirandola, Modena) and acrylonitrile and sodium methallyl sulfonate copolymer filter membranes, surface of filters 1.0 to 1.5 sqm, blood flow 150 to 200 ml/min, dialysate flow <150 ml/min, length 8 to 12 hours daily with a target of 25 ml/kg/h of effluent rate (except for septic shock = 45 ml/kg/h).

(2) *Intermittent standard HD and hemodiafiltration (HDf)*: dialysis performed with standard or portable monitor (Diapact, Braun Carex, BRAUN-Avitum Italia, Mirandola, Modena), filter membranes polysulphone, surface ≥1.8 sqm, blood flow >200 ml/min, dialysate flow >150 ml/min, length from 2 to 4 hours; in the case of HDf, the total exchange volume was 12 to 16 L/treatment.

### 2.6. Statistical analysis

Continuous variables are expressed as mean ± standard deviation. Categorical variables are expressed as a proportion. The comparisons of quantitative and qualitative variables between groups were made by one-way analysis of variance, Student $t$ test, and $\chi^2$ test, as appropriate. Point estimates and 95% confidence intervals for between-group differences were also reported. In survival analysis, death and the need to continue dialysis after hospital discharge were considered as outcomes. Receiver operating characteristic (ROC) curve (as a measure of discrimination) and Hosmer–Lemeshow test (as an index of calibration) were computed to investigate the mortality prediction ability of simplified acute physiology score (SAPS 2) and sequential organ failure assessment (SOFA) score, and therefore to evaluate the prognostic impact of acute disease and differences of patients. Cox survival analysis was performed, adjusting in a stepwise mode, to explore the relationship between mortality and variables such as year of admittance, age, comorbidity, SAPS 2, and others. Two-sided $P$ value <0.05 was considered statistically significant. All data were entered into a database (Excel) and then analyzed with the statistical program SPSS 23.0 (IBM-SPSS statistics).

### 2.7. Propensity score matching

This study was a matched cohort study using 2 groups of patients: the first group consisted of NEPHROpts, the second of patients admitted to and in care of medicine wards (MEDpts). The patients were matched 1:1 by PS model using the greedy matching

### Table 1

**Characteristics of the patients admitted to nephrology or medical ward at the moment of first nephrology consultation.**

| Variable | Nephrology | Medical wards | P | Mean difference | 95% CI |
|---|---|---|---|---|---|
| Age, y | 69.9±12.6 | 71.7±12.7 | 0.31 | 1.79 | −1.7, 5.3 |
| s.Proteins, g/dL | 6.3±0.9 | 6.3±0.8 | 0.96 | 0.007 | −0.24, 0.25 |
| s.Albumin, g/dL | 3.5±0.6 | 3.4±0.6 | 0.34 | −0.82 | −0.25, 0.08 |
| Hemoglobin, g/dL | 10.7±1.9 | 10.9±2.3 | 0.52 | 1.93 | −0.40, 0.79 |
| White blood cells, $\times 10^3 \, mm^3$ | 11.3±5.7 | 12.4±6.8 | 0.19 | 0.11 | −0.6, 2.9 |
| s.Creatinine, mg/dL | 6.8±3.5 | 4.6±2.6 | <0.001 | −2.24 | −3.12, −1.37 |
| p.Potassium, mEq/L | 5.1±1.2 | 4.8±1.1 | 0.18 | −0.22 | −0.56, 0.10 |
| pH | 7.3±0.15 | 7.33±0.12 | 0.11 | 0.03 | −0.07, 0.67 |
| SOFA score | 5.6±2.2 | 5.8±2.3 | 0.45 | 0.24 | −0.39, 0.87 |
| SAPS 2 score | 45.5±13.6 | 46.1±13.2 | 0.73 | 1.89 | −3.1, 4.3 |
| Charlson index | 5.5±2.7 | 6.1±2.9 | 0.64 | 0.47 | −0.15, 1.45 |

CI = confidence interval, SAPS 2 = simplified acute physiology score, SOFA = sequential organ failure assessment.

algorithm. The algorithm first made the best matches and then the next–best matches, in a hierarchical sequence. We derived the PS from a multilogistic regression model based on the following variables: age, sex, SAPS 2 score, RIFLE, causes of AKI, presence of diabetes mellitus, ischemic heart disease or congestive heart failure, chronic kidney disease (CKD), sepsis, noradrenaline or dopamine treatment. After all PS matches were performed, we assessed the balance in baseline covariates. PS matching was conducted using SPSS 23.0.

## 3. Results

### 3.1. Patient characteristics and site of treatment

A total of 948 AKI patients with or without CKD were treated with HD: 654 patients were not in the charge of ICU during hospitalization. After considering inclusion and exclusion criteria, 296 patients were enrolled for matching, 161 in nephrology and 135 in medical wards. Overall, their age was

70.4±13.1 years (range 20–85 years), 64.2% were males (190 patients). PS matching resulted in 2 groups: 100 patients in-care of nephrology and 100 patients of medical wards. Patient's characteristics are resumed in Table 1. Score for acute disease did not differ between the 2 groups. We have investigated which score system could represent the best marker for acute disease. SAPS 2 score has a higher area under curve at ROC analysis when compared with SOFA (SOFA: AUC=0.67, $P < 0.001$, 95% CI: 0.59–0.75; SAPS 2: AUC=0.68, $p < 0.001$, 95% CI: 0.61–0.75; Hosmer–Lemeshow test: SOFA=$\chi^2$ 6.43, $P = 0.26$; SAPS 2=$\chi^2$ 5.02, $P = 0.75$) (Fig. 1). Comorbid conditions were similar in nephrology and medical patients (Table 2). Differences in s. Creatinine level persisted at the moment of dialysis inception (medical=5.1±2.4 mg/dL vs nephrology=7.2±3.4 mg/dL; $P < 0.001$; 95% CI: −2.98, −1.34).

### 3.2. AKI-D causes and classification (RIFLE score)

We haven't reported differences on AKI causes (Table 3). AKI RIFLE score revealed that the majority of patients were in class F at the moment of HD beginning (nephrology 86% and medical 81%).

### 3.3. Type of dialysis treatment

We have done daily dialysis treatments; SLED-f was performed in 19% of patients (nephrology=17%; medical wards=21%).

A higher blood urea nitrogen (BUN)/s.Creatinine ratio at the moment of dialysis beginning was present in MEDpts (nephrology=18.9±12.7, medical=23.4±12.8; $P = 0.01$; 95% CI: 0.97, 8.11).

We haven't reported differences in urea reduction rate (URR) and length of treatment between the 2 groups.
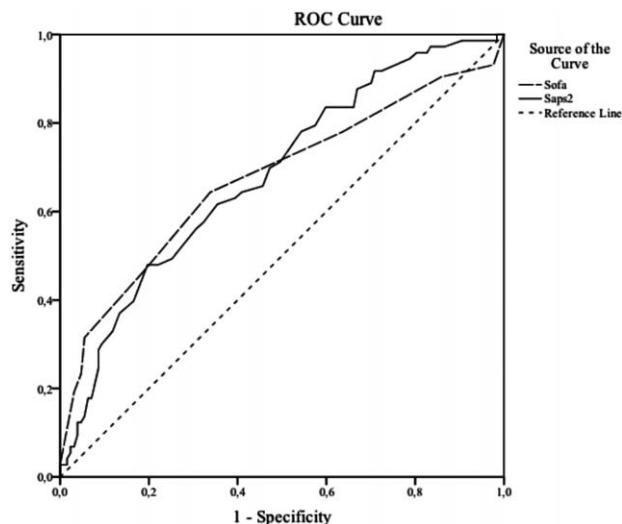


**Figure 1.** Sequential organ failure assessment (SOFA) and simplified acute physiology score (SAPS 2) prediction of mortality: receiver operating characteristic analysis. SOFA: area under curve=0.67, 95% confidence interval (CI): 0.59, 0.75, statistical significance <0.001. Hosmer–Lemeshow goodness-of-fit test: $\chi^2$=6.43, $P = 0.26$. SAPS 2: area under curve=0.68, 95% CI: 0.61, 0.75, statistical significance <0.001. Hosmer–Lemeshow goodness-of-fit test: $\chi^2$=5.02, $P = 0.75$.

### Table 2

**Comorbidities of the patients admitted to nephrology or medical ward.**

| Variable | Nephrology (100 patients) (%) | Medical wards (100 patients) (%) | P |
|---|---|---|---|
| Diabetes type 2 | 40 | 42 | 0.88 |
| Heart disease | 59 | 67 | 0.30 |
| Sepsis | 26 | 28 | 0.87 |
| Chronic kidney disease | 66 | 68 | 0.88 |
| Noradrenaline/dopamine | 6 | 10 | 0.43 |

### Table 3

**Causes of acute kidney injury.**

| AKI group | Cause | NEPHROpts (n = 100) | MEDpts (n = 100) | $\chi^2$ | Sig. |
|---|---|---|---|---|---|
| Prerenal | | 69 | 73 | 0.38 | 0.64 |
| | Dehydration | 47 | 50 | 0.180 | 0.77 |
| | Decompensated heart failure | 18 | 23 | 0.76 | 0.48 |
| | Renal artery stenosis | 4 | 0 | 4.08 | 0.12 |
| Renal | | 77 | 23 | 0.42 | 0.62 |
| | Septic shock | 3 | 3 | 0 | 1 |
| | Toxic interstitial nephropathy | 12 | 14 | 0.17 | 0.83 |
| | Contrast media | 2 | 2 | 0 | 1 |
| | Glomerulonephritis | 0 | 2 | 2.02 | 0.49 |
| | Vasculitis | 6 | 2 | 2.08 | 0.27 |
| | Rhabdomyolysis | 3 | 1 | 1.06 | 0.62 |
| Unknown | | 4 | 4 | 0 | 1 |

AKI = acute kidney injury, MEDpts = patients admitted to and in care of medicine wards, NEPHROpts = patients admitted to and in care of nephrology, Sig. = significance.

### Table 4

**Characteristics of death and survival patients: differences in continuous and categorical variables.**

| Variable | Death group | Survival group | P | Mean difference | 95% CI |
|---|---|---|---|---|---|
| Age, y | 74.8 ± 9.6 | 68.5 ± 13.6 | 0.001 | 6.28 | 3.02, 9.54 |
| s.Creatinine, mg/dL | 4.5 ± 2.6 | 6.4 ± 3.5 | <0.001 | −1.87 | −2.80, −0.95 |
| s.Creatinine HD, mg/dL | 5 ± 2.5 | 6.8 ± 3.2 | <0.001 | −1.81 | −2.62, −0.99 |
| BUN/s.Creatinine | 23.8 ± 11.1 | 19.6 ± 13.7 | <0.05 | 4.19 | 0.67, 7.71 |
| URR | 0.45 ± 0.11 | 0.49 ± 0.12 | 0.01 | −0.40 | −0.73, −0.01 |
| SAPS 2 score | 51.1 ± 13.1 | 42.9 ± 12.6 | <0.001 | 8.16 | 4.49, 11.92 |
| Charlson score | 6.7 ± 2.8 | 5.2 ± 2.7 | 0.001 | 1.40 | 0.69, 2.31 |

| Variable | Death group | Survival group | P | $\chi^2$ |
|---|---|---|---|---|
| Heart disease | 72.6% (53/57) | 57.5% (73/127) | 0.035 | 4.5 |
| Noradrenaline/dopamine | 17.8% (13/73) | 2.4% (3/127) | <0.001 | 15.02 |

BUN = blood urea nitrogen, CI = confidence interval, HD = hemodialysis, SAPS 2 = simplified acute physiology score, URR = urea reduction rate.

#### 3.4. Endpoint: mortality

Overall mortality was 36%. A difference was reported between nephrology and medical wards (20% vs 52%, $\chi^2 =$ 23.2, $P < 0.001$). Patients who died differed in age, serum creatinine, BUN/s.Creatinine ratio, URR, SAPS 2 and Charlson score; they presented a higher rate of heart disease, and a larger proportion required noradrenaline/dopamine for shock treatment (Table 4).

After correction for confounding variables, multivariate Cox analysis revealed that the site of treatment corresponding to medical wards represents an independent risk factor of mortality (RR = 2.13, 95% CI = 1.25, 3.63; $P = 0.005$) (Fig. 2). Other independent risk factors of mortality were patient's age, URR, s.Creatinine at the moment of dialysis beginning, and SAPS 2 score (Table 5).

#### 3.5. Secondary endpoints: dialysis need at hospital discharge

One hundred twenty-eight patients survived after AKI-D, 92 did not require HD treatment at hospital discharge, but 28% of surviving population needed to continue dialysis, without differences between nephrology and medical wards (31% vs 23%). Patients who remained on HD treatment in a larger proportion had previous CKD, 75% (27/36), in comparison with 40.2% patients HD-free (37/92) ($\chi^2 = 12.5$, $P = 0.001$). HD-dependent patients had lower levels of hemoglobin (HD-dependent = 10.0 ± 1.6, HD-free = 11.1 ± 1.9 g/dL, $P < 0.01$; 95%

CI: −1.74, −0.30) and higher levels of s.Creatinine at the time of first diagnosis (8.3 ± 3.9 and 5.7 ± 3 mg/dL, $P = 0.001$; 95% CI: 1.13, 4.04) and HD beginning (8.5 ± 3.8 and 6.2 ± 2.7 mg/dL, $P < 0.01$; 95% CI: 0.92, 3.71). No differences were reported in
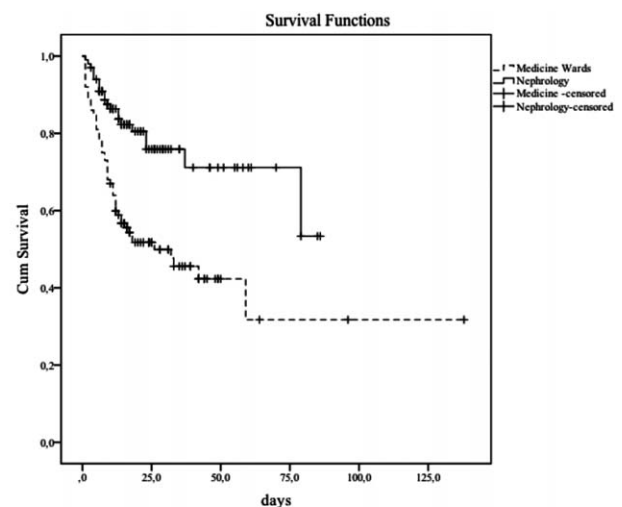


Log Rank (Mantel-Cox): $\chi^2 =$ 16.01    $p < 0.001$

**Figure 2.** Kaplan–Meier survival analysis: cumulative survival of patients with acute kidney injury requiring hemodialysis, depending on wards of treatment.

**Table 5**

Survival analysis, multivariate Cox model: in-hospital mortality independent risk factors.

| | B | SE | Wald | df | Sig. | Hazard ratio | 95% CI | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age, y | 0.026 | 0.013 | 3.870 | 1 | 0.049 | 1.026 | 1.000 | 1.053 |
| Medical wards | 0.780 | 0.278 | 7.875 | 1 | 0.005 | 2.181 | 1.265 | 3.761 |
| s.Creatinine, mg/dL | −0.122 | 0.051 | 5.825 | 1 | 0.016 | 0.885 | 0.801 | 0.977 |
| URR | −2.442 | 1.108 | 4.856 | 1 | 0.028 | 0.087 | 0.010 | 0.763 |
| SAPS 2 score | 0.034 | 0.009 | 15.809 | 1 | 0.000 | 1.035 | 1.018 | 1.053 |

CI = confidence interval, df = degree of freedom, SAPS 2 = simplified acute physiology score, SE = standard error, Sig. = significance, URR = urea reduction rate.

age, gender, type of treatment, HD dose, heart disease or diabetes comorbidities. Following multivariate analysis, CKD represents an independent risk factor of dialysis need at hospital discharge (RR = 2.75, $P < 0.01$; 95% CI: 2.19, 5.91).

Fifty percent of surviving patients (64/128) did not have a history of CKD, but only 21.8% of them fully restored a normal kidney function, independent of site of care.

## 4. Discussion

This is a prospective observational study conducted over an 8-year span in a single regional teaching hospital, which serves a population of about 354,000 inhabitants. In our previous study, we have documented that 2/3 of patients with AKI-D were not admitted to ICU, and their mortality rate was about 40%. We observed that year after year fewer patients were in-care to nephrology ward, the majority of them being admitted to medicine wards. We concluded that the trend of AKI and the documented change of medical specialty involved in the diagnosis and therapy could indicate the necessity for updating resources and organization.[9] Consequently, the question arising concerns possible survival differences between AKI-D patients admitted to or in-care of nephrology department or other medical wards.

The results of the present study seem to suggest that "specialized medical closed-staff wards", such as a nephrology department, result in better hospital outcome in terms of mortality than other medical wards: 20% versus 52%. The results, if true, confirm the need for different healthcare organizations, resources, professional skills, work planning, and quantitative funding.

It is widely accepted that AKI epidemiology has changed dramatically in the last 20 years, and studies are mainly confined to critically ill patients necessitating ICU, a minority of the involved population.

Challiner et al,[11] analyzing data of a large UK hospital trust, not confined to ICU, observed an AKI incidence close to 25%, with patients requiring longer hospital stays, a higher number of ICU hospitalization days, and a higher mortality. Barrantes et al[12] similarly observed in noncritically ill patients a longer in-hospital stay, higher rate to ICU transfer, mortality, and at hospital discharge AKI patients required extended care facilities in a higher percentage. Faced with the increased need of care for AKI, the dimension and resources of the nephrology departments did not change in proportion, and a larger number of patients needed to be admitted to or remain in the care of nonspecialized kidney departments. Kolhe et al[13] observed, during a period from 1998 to 2013, a decrease in England of AKI-D patients treated in specialist nephrology department and a contrasting trend of increased AKI-D care in nonmedical wards.

Mortality varies widely between hospitals and one of the reasons could be the gravity of patients or differences in dialysis treatment strategies. The type of organization, that is, the structure or the model of the healthcare system, which will provide AKI diagnosis and treatment, could have a role in hospital outcome. Abraham et al[14] observed that only hospitals with "visit renal input" had a higher AKI adjusted in-hospital and 30-day mortality than those with renal transplant unit or on-site renal departments.

Early nephrology consulting resulted in lower mortality,[15] reduction of kidney dysfunction progression,[16] and of dialysis dependence for survivors,[17] and this approach depended on internal procedures and organization.

We can easily imagine that hospitals without an on-site nephrology department may not be able to guarantee an early specialist intervention, even if they can ask for a nephrology consultation to other trusts.

The site of care may be associated with differences of AKI assessment procedures: Stevens et al[18] observed that AKI patients in-care to surgery wards received less renal tract imaging, assessment of acid–base and oxygen state compared with patients admitted to medical wards.

AKI diagnosis and treatment is a complex procedure: medical doctors and staff should be properly trained and skills improvements need to be implemented. "The National Confidential Enquiry into Patients Outcome" report developed in the UK has revealed situations of organization failure, as well as cultural inadequacy.[19]

There is a link between knowledge, clinical experience, volume of activity, and outcome.

Aitken et al[20] evaluated in a single hospital the process and quality of care in a cohort of patients with AKI. They observed that about half of patients were admitted to hospital out of the normal working hours. Younger doctors, with less than 2 years of clinical experience, have firstly evaluated a third of them. About 25% of patients had a completely unrecognized AKI, and a delay was present in about 20% of cases. The cause of this phenomenon was attributed to clinical inexperience, inadequate clinical review, inadequate observation or investigation, and infrequent clinical review. Muniraju et al[21] seems to confirm the knowledge deficiency of nonspecialist trainee medical staff.

In the setting of emergency admissions, clinical competence, defined on the basis of years of clinical experience, correlates inversely with in-hospital mortality and length of stay.[22]

This suggestion could also be applicable to AKI, if it is true that weekend hospital admissions represent an independent risk factor of mortality, particularly in small- and medium-size hospitals, where the availability of trained personnel may be reduced on Sunday.[23]

Knowledge and clinical competence is possible in the setting of trusts with high-volume activity, and therefore the dimension of hospitals and training of staff involved in AKI treatments seem to be relevant.[24]

Other studies seem to confirm this hypothesis,[25] although some of them did not specifically test for AKI,[26] raising, therefore, challenging questions about reduced service provision at weekend. Wilson et al[27] observed that weekend mortality was not increased in the setting of hospitals with a kidney service able to guarantee not only consulting 7d/wk, but also dialysis treatment.

Hospitals with a high volume of acute admissions seem to have a lower adjusted case fatality rate and 28-day readmission with the adoption of continuity of care and regular review of patients by specialists.[28]

Without any doubt, a well organized nephrology team, where nurses and physicians are specially trained and educated to manage AKI and to perform RRT, seems able to reduce mortality rate, at least for critically ill patients.[29]

In the abovementioned context, we can position the results of our study: a difference in mortality rate exists if patients with AKI-D are in-care to a nephrology or to other medical wards. Some hypotheses can be made: different training and expertise can lead to differences of diagnostic approach, management of fluids, pharmacological therapy, nutritional support, but also differences in medical team workload could have consequences on outcome. In the specific case, workload can be considered similar between different wards, although differences exist in the characteristics of medical activity, as reported in the "Perugia Hospital Annual Report of Activities".[10]

The other point to consider is the consulting activity toward medical wards: what happens in the case where a "dedicated intensive Nephrology AKI team" is not present in the hospital organization? Paradoxically, the required nephrology expertise can lead to different diagnostic procedures or therapeutic approach, as the result of variations in knowledge, expertise, and clinical practice of consultants. Looking at the study of Held et al,[30] we can reasonably suspect that organizations with an open staff and a larger number of doctors have a higher mortality, probably because the continuity of the medical process is better accomplished in a closed-staff model. The higher mortality in open-staff organization could be the result of a large number of consultants that rotate every day without clinical discussion and transmission of the individual diagnostic or therapeutic approach.

As a consequence, the demonstration that in-hospital mortality is lower when patients are in-care to nephrology instead of medical wards can be the result of a closed-staff organization, where a larger medical continuity is possible.

Our study has several limitations, consistent with the bias that such investigations possess. First, the study was conducted at a single institution and the result may not be directly extrapolated to other patterns of nephrology and other physicians across healthcare facilities. Second, a bias could be the cause of admittance. Although we applied several exclusion criteria, we cannot exclude that some differences exist, as it is a known fact that generally nephrology department admittance is due to a reduced kidney function. Only a randomized study can solve this doubt, but it is easily understandable that ethics considerations would exclude it.

Further investigations with multicenter studies are needed to confirm our observation.

In conclusion, our study on AKI-D, which used strict exclusion criteria and a PS matching to solve bias and differences between groups, has demonstrated that noncritically ill AKI-D patients represent 2/3 of the entire population, with a mortality of 36%. Only a minority of surviving patients recovered kidney function,

about 25% of them needed to continue dialysis treatment at hospital discharge. Residual kidney damage was present in about 80% of surviving patients with a previously normal renal function. A lower mortality seems to be present if patients are in-care to nephrology, a "closed-staff" organization, instead of medical wards. Larger studies, possibly randomized, are needed because these observations, if confirmed, indicate the necessity to review the healthcare system in terms of organization, knowledge improvement, internal procedures development, and funding.

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