Intensive Care Med (2013) 39:420–428
DOI 10.1007/s00134-012-2796-5

ORIGINAL

Incidence, risk factors and 90-day mortality of patients with acute kidney injury in Finnish intensive care units: the FINNAKI study

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Received: 21 June 2012
Accepted: 23 October 2012
Published online: 5 January 2013

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Abstract *Purpose:* We aimed to determine the incidence, risk factors and outcome of acute kidney injury (AKI) in Finnish ICUs. *Methods:* This prospective, observational, multi-centre study comprised adult emergency admissions and elective patients whose stay exceeded 24 h during a 5-month period in 17 Finnish ICUs. We defined AKI first by the Acute Kidney Injury Network (AKIN) criteria supplemented with a baseline creatinine and second with the Kidney Disease: Improving Global Outcomes (KDIGO) criteria. We screened the patients' AKI status and risk factors for up to 5 days. *Results:* We included 2,901 patients. The incidence (95 % confidence interval) of AKI was 39.3 % (37.5–41.1 %). The incidence was 17.2 % (15.8–18.6 %) for stage 1, 8.0 % (7.0–9.0 %) for stage 2 and 14.1 % (12.8–15.4 %) for stage 3 AKI. Of the 2,901 patients 296 [10.2 % (9.1–11.3 %)] received renal replacement therapy. We received an identical classification with the new KDIGO criteria. The population-based incidence (95 % CI) of ICU-treated AKI was 746 (717–774) per million population per year (reference population: 3,671,143, i.e. 85 % of the Finnish adult population). In logistic regression, pre-ICU hypovolaemia, diuretics, colloids and chronic kidney disease were independent risk factors for AKI. Hospital mortality (95 % CI) for AKI patients was 25.6 % (23.0–28.2 %) and the 90-day mortality for AKI patients was 33.7 % (30.9–36.5 %). All AKIN stages were independently associated with 90-day mortality. *Conclusions:* The incidence of AKI in the critically ill in Finland was comparable to previous large multi-centre ICU studies. Hospital mortality (26 %) in

AKI patients appeared comparable to or lower than in other studies.

Keywords Acute kidney injury · Epidemiology · Intensive care · Outcome · Mortality · AKIN · KDIGO

Introduction

Acute kidney injury (AKI) frequently complicates the course of critical illness and is associated with a substantial increase in morbidity and mortality. AKI, defined as a reduction in glomerular filtration rate (GFR) occurring during hours or days and leading to disturbances in fluid and electrolyte balance, is a multi-etiological disorder with a few known risk factors [1]. The detailed pathogenesis of AKI is still unclear [2, 3]. The current consensus for diagnosing and staging AKI has been the Acute Kidney Injury Network's (AKIN) modification of the original RIFLE criteria (2007) [4]. The AKIN criteria divide AKI into three grades of severity (stages 1–3) based on urine output and serum/plasma creatinine (Cr) levels. In 2012 the Kidney Disease: Improving Global Outcomes (KDIGO) foundation published a new guideline for defining and classifying AKI in which the AKIN criteria are supplemented with some small changes [5]. The original RIFLE criteria have been validated in over half a million patients [6]. All RIFLE grades are independently predictive for hospital mortality [7]. The overall incidence of AKI in hospitalised patients has been reported as 20 % [8], but up to 67 % in the critically ill [9, 10]. Sepsis in particular is often complicated by AKI. Recent data suggest that the incidence of AKI is increasing [11].

AKI is associated with dismal outcomes. Hospital mortality of patients with stage 3 (RIFLE F) AKI is approximately 40 % [12], and the 5-year mortality is up to 70 % [13]. Even small and transient changes in serum/plasma Cr are associated with increased mortality [14].

No prospective population-based studies on the incidence of AKI in intensive care units (ICU) defined by the RIFLE, AKIN or the KDIGO criteria exist. Therefore, in this nationwide multi-centre, prospective observational cohort study we aimed to determine the incidence, risk factors and outcome of AKI in Finnish ICU patients.

Materials and methods

Data source

Seventeen Finnish ICUs participated in this prospective, observational study between 1 September 2011 and 1 February 2012 (a 5-month period). The Ethics Committee of the Department of Surgery in Helsinki University Hospital gave the nationwide approval for the study and for a deferred consent policy from the patient or proxy. The Finnish National Institute of Health and Welfare approved collection of data from medical records regarding deceased patients.

For the incidence calculations we obtained the number of adult (>18 years) population in the area of the participating hospitals from Statistics Finland (http://www.stat.fi, accessed 31 Dec 2011). The number of adult patients on chronic renal replacement therapy ($N = 1{,}527$) according to the Finnish Registry for kidney diseases [15] was extracted from the population. The total reference population for the calculations was 3,671,143 representing 85 % of the Finnish adult population.

Patients

We included (1) all emergency ICU admissions and (2) all elective patients with an ICU stay longer than 24 h. We excluded (1) patients under 18 years of age, (2) readmitted patients who received renal replacement therapy (RRT) during their previous admission, (3) elective ICU patients treated for less than 24 h if discharged alive, (4) patients on chronic dialysis, (5) organ donors, (6) patients with no permanent residency in Finland or insufficient language skills, (7) transferred patients included in the study for 5 days and (8) intermediate care patients. Thus, each patient was included only once.

Definitions

Our AKI definition followed the AKIN modification of the original RIFLE criteria (later as AKIN) [4] with a continuous moving baseline for both the Cr and urine output. When available, we used Cr and urine output data starting from 48 h preceding ICU admission. Concerning the Cr-based staging we applied the requirement for the acute rise within 48 h. However, owing to evident limitations in the AKIN criteria in identifying all AKI patients [12], we modified the AKIN by adding a baseline preceding critical illness which was the most recent value from the previous year excluding the week preceding admission. If baseline Cr was not available we estimated it using the modification of diet in renal disease (MDRD) equation assuming a GFR of 75 ml/min/1.73 m^2 [16]. Retrospectively, we recalculated the AKI staging using the newest KDIGO criteria [5]. We screened AKI and AKI risk factors at admission and during the first 5 days of admission including severe sepsis and disseminated intravascular coagulation (DIC) using the American

College of Chest Physicians/Society of Critical Care Medicine (ACCP/SCCM) and International Society on Thrombosis and Haemostasis (ISTH) criteria [17, 18]. For each patient the highest AKIN stage served as the value for the incidence calculations. For re-admitted patients we chose the admission with the highest AKIN stage. The study entry time was ICU admission time.

Data collection

At the time of the study the Finnish Intensive Care Consortium (FICC) comprised 25 ICUs in university or central hospitals across Finland. The consortium maintains a database (Tieto Ltd, Helsinki, Finland), where routine data including demographics, ICU scores, length of stay (LOS), physiologic data and hospital mortality are prospectively collected. We measured serum/plasma Cr daily and urine output hourly and calculated an AKIN stage for each patient continuously based on every measured hourly urine output and Cr value. The AKIN stage calculations for the urine output criteria were performed by an automated calculator integrated into the study database. To augment the data collected by the database we completed a standardized case report form (CRF) at admission, daily for 5 days and at ICU discharge. The CRF data comprised of chronic and present health status, medications, detailed information on possible risk factors for AKI, evaluation of severe sepsis, DIC, other organ dysfunction, fluid balance and information on possible RRT. This additional study-specific CRF comprised 54 % of the study dataset variables. We monitored the reliability and completeness of the CRF data in eight randomly chosen study sites using a structured monitoring plan.

Statistical analyses

We analysed the data by using SPSS version 19 (SPSS, Chicago, Ill., USA). We present the data as medians with interquartile ranges (IQR), or as absolute numbers [percentage with 95 % confidence intervals (CI)]. We compared groups using the Mann–Whitney *U* test for continuous data and Fisher's exact test or χ^2 test for categorical data, when applicable. Hospital mortality rates between different groups were compared by the χ^2 test. First, we analysed the association between AKI and risk factors by a univariate analysis. Second, we calculated independent odds ratios (OR with 95 % CI) for risk factors by backward conditional stepwise logistic regression analysis. A p value less than 0.05 was considered as statistically significant in all analyses.

Results

Altogether 2,901 patients were included in the study. The study flow chart is presented as Fig. 1. Baseline

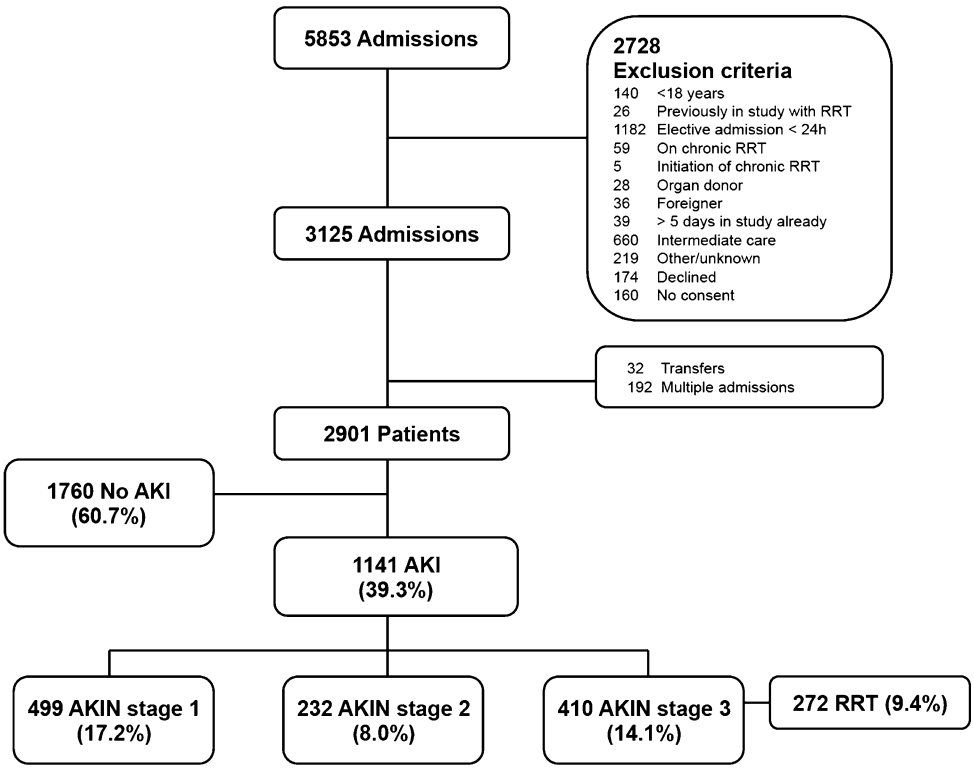

Fig. 1 Study flow chart. Critically ill patients stratified by AKI using highest Acute Kidney Injury Network (AKIN)/Kidney Disease: Improving Global Outcomes (KDIGO) stage. *AKI* acute kidney injury, *RRT* renal replacement therapy

characteristics of the study patients are presented in Table 1. The incidence (95 % CI) of AKI was 1,141/2,901 patients [39.3 % (37.5–41.1 %)]; including stage 1 AKI in 499 patients [17.2 % (15.8–18.6 %)], stage 2 AKI in 232 patients [8.0 % (7.0–9.0 %)] and stage 3 AKI in 410 patients [14.1 % (12.8–15.4 %)]. Retrospectively, the KDIGO criteria gave exactly the same AKI classification. Of the 2,901 patients, 296 [10.2 % (9.1–11.3 %)] received renal replacement therapy, of whom 272 (91.9 %) during the first five ICU days (Fig. 1). Table 2 illustrates the characteristics of the AKI patients according to their highest AKIN stage. The population-based incidence (95 % CI) of ICU-treated AKI was 746 (717–774) per million population (pmp) per year.

The majority of AKI patients ($N = 950$, 83 %) had AKI at admission or during the first two ICU days. The progression of AKI is presented as Fig. 2. Including all risk factors, preceding AKI severe sepsis, pre-ICU hypovolaemia and pre-ICU hypotension were more frequent in patients with AKI (Table 3). In a multivariable logistic regression analysis [covariates entered: pre-ICU hypovolaemia, pre-ICU use of diuretics, pre-ICU use of colloids (52 % gelatin, 40 % starch and 8 % both), hypertension and chronic kidney disease] pre-ICU hypovolaemia [OR (95 % CI) 2.20 (1.85–2.62)], pre-ICU use of diuretics [OR (95 % CI) 1.68 (1.41–2.00)] or colloids [OR (95 % CI) 1.35 (1.13–1.61)] and chronic kidney disease [OR (95 % CI) 2.64 (1.88–3.71)] were independent risk factors for AKI.

The median ICU LOS (interquartile range) for AKI patients was 3.7 (1.9–6.4) days compared to that of 1.9 (1.0–4.0) in patients without AKI ($P < 0.001$). Of the 1,141 AKI patients 853 (74.8 %) received mechanical ventilation compared to 1,159 (65.9 %) of patients without AKI ($P < 0.001$). Overall hospital mortality (95 % CI) for AKI patients was 292/1,141 [25.6 % (23.0–28.2 %)] compared to 179/1,760 [10.2 % (8.7–11.6 %)] in patients with no AKI. The 90-day mortality (95 % CI) for patients with and without AKI was 385/1,141 [33.7 % (30.9–36.5 %)] versus 293/1,760 [16.6 % (14.9–18.4 %)], respectively. There was a linear increase in the 90-day mortality (95 % CI) with advancing stage of AKI: 29.3 % (25.2–33.3 %) for stage 1, 34.1 % (27.8–40.3 %) for stage 2 and 39.0 % (34.2–43.8 %) for stage 3. Of the patients who received RRT, 116/296 [39.2 % (38.6–39.8 %)] had died and 34/296 [11.5 % (7.8–15.2 %)] were still dependent on RRT at day 90. The 90-day survival of patients with and

Table 1 Characteristics of critically ill patients ($N = 2,901$) by presence of AKI by both AKIN and KDIGO stages

	Data available	No AKI ($N = 1,760$)	AKI ($N = 1,141$)	P
Age (years)	2,901	62.0 (49.0–72.0)	66.0 (55.0–75.0)	<0.001
Gender (male)	2,901	1091 (62.0)	755 (66.2)	0.012
Baseline serum/plasma creatinine (μmol/l)	1,847	73.0 (60.0–90.0)	78.0 (65.0–100.0)	<0.001
SAPS II score (points)	2,901	33.0 (25.0–44.0)	43.0 (33.0–58.0)	<0.001
SOFA (first 24 h, points)	2,901	6.0 (4.0–8.0)	9.0 (7.0–12.0)	<0.001
SOFAmax (non-renal score, points)	2,901	6.0 (4.0–8.0)	8.0 (6.0–10.0)	<0.001
Mechanical ventilation during ICU stay	2,901	1159 (65.9)	853 (74.8)	<0.001
Vasoactive treatment during ICU stay	2,901	940 (53.4)	891 (78.1)	<0.001
Highest lactate (24 h, mmol/l)	2,411	1.9 (1.3–2.9)	2.7 (1.7–5.1)	<0.001
Emergency surgery (<1 week)	2,897	366 (20.8)	279 (24.5)	0.012
Admission type				
Emergency	2,870	1,531 (87.9)	1,013 (89.7)	0.078
Post-operative	2,900	628 (35.7)	382 (33.5)	0.123
Comorbidity				
Chronic obstructive pulmonary disease	2,883	148 (8.4)	116 (10.3)	0.058
Hypertension	2,885	749 (42.8)	630 (55.5)	<0.001
Arteriosclerosis	2,870	194 (11.1)	186 (16.5)	<0.001
Diabetes	2,897	345 (19.6)	292 (26.6)	<0.001
Systolic heart failure	2,874	176 (10.1)	159 (14.1)	0.001
Chronic kidney disease	2,889	67 (3.8)	122 (10.8)	<0.001
Medication				
ACE inhibitor or ARB	2,839	555 (32.3)	481 (43.0)	<0.001
NSAID	2,785	129 (7.6)	113 (10.3)	0.01
Diuretic	2,847	398 (23.1)	410 (36.4)	<0.001
Aspirin	2,845	449 (26.0)	334 (29.8)	0.016
Metformin	2,854	188 (10.9)	161 (14.3)	0.004
Statin	2,856	471 (27.2)	389 (34.5)	<0.001
Corticosteroids	2,864	118 (6.8)	104 (9.2)	0.011

Values are expressed as median (IQR) or count (percentage)
AKI acute kidney injury, *AKIN* Acute Kidney Injury Network, *KDIGO* Kidney Disease: Improving Global Outcomes, *SAPS II* Simplified Acute Physiology Score, *SOFA* Sequential Organ Failure Assessment, *SOFAmax* highest SOFA score during admission, *ACE* angiotensin-converting enzyme, *ARB* angiotensin II receptor blocker, *NSAID* non-steroidal anti-inflammatory drug

Table 2 Characteristics of AKI patients ($N = 1{,}141$) stratified by both AKIN and KDIGO stages

	Data available	Stage 1 ($N = 499$)	Stage 2 ($N = 232$)	Stage 3 ($N = 410$)
Age (years)	2,901	66.0 (56.0–75.0)	66.0 (56.0–76.0)	65.0 (55.0–75.0)
Gender (male)	2,901	328 (65.7)	150 (64.7)	277 (67.6)
Baseline serum/plasma creatinine (μmol/l)	1,847	78.0 (65.0–96.5)	75 (62.0–88.0)	82.0 (65.5–110.0)
SAPS II score (points)	2,901	39.0 (30.0–51.0)	42 (33.0–57.0)	51.0 (39.0–65.0)
SOFA (first 24 h, points)	2,901	8.0 (6.0–10.0)	9.0 (7.0–11.0)	11.0 (9.0–14.0)
SOFAmax (non-renal score, points)	2,901	7.0 (6.0–10.0)	8.0 (6.0–10.0)	9.0 (6.0–11.0)
Mechanical ventilation during ICU stay	2,901	398 (79.8)	168 (72.4)	287 (70.0)
Vasoactive treatment during ICU stay	2,901	387 (77.6)	186 (80.2)	318 (77.6)
Highest lactate (24 h, mmol/l)	2,411	2.3 (1.6–3.8)	2.9 (1.9–5.4)	3.7 (1.8–8.2)
Emergency surgery (<1 week)	2,897	123 (24.7)	52 (22.4)	104 (25.4)
Admission type				
Emergency	2,870	427 (86.8)	203 (88.3)	383 (94.1)
Surgical	2,900	186 (37.3)	77 (33.2)	119 (29.1)
Comorbidity				
Chronic obstructive pulmonary disease	2,883	51 (10.3)	30 (12.9)	35 (8.6)
Hypertension	2,885	278 (56.3)	130 (56.0)	222 (54.3)
Arteriosclerosis	2,870	84 (17.1)	40 (17.4)	62 (15.2)
Diabetes	2,897	111 (22.2)	56 (24.2)	125 (30.5)
Systolic heart failure	2,874	61 (12.4)	39 (16.8)	59 (14.7)
Chronic kidney disease	2,889	46 (9.3)	13 (5.6)	63 (15.5)
Medication				
ACE inhibitor or ARB	2,839	203 (41.9)	100 (43.5)	178 (44.1)
NSAID	2,785	42 (8.8)	25 (11.2)	46 (11.6)
Diuretic	2,847	180 (36.8)	94 (41.0)	136 (33.4)
Aspirin	2,845	152 (31.3)	61 (26.6)	121 (29.8)
Metformin	2,854	60 (12.4)	29 (12.6)	72 (17.6)
Statin	2,856	162 (33.2)	78 (33.9)	149 (36.5)
Corticosteroids	2,864	41 (8.4)	19 (8.3)	44 (10.8)

Values are expressed as median (IQR) or count (percentage)
AKI acute kidney injury, *AKIN* Acute Kidney Injury Network, *KDIGO* Kidney Disease: Improving Global Outcomes, *SAPS II* Simplified Acute Physiology Score, *SOFA* Sequential Organ Failure Assessment, *SOFAmax* highest SOFA score during admission, *ACE* angiotensin-converting enzyme, *ARB* angiotensin II receptor blocker, *NSAID* non-steroidal anti-inflammatory drug

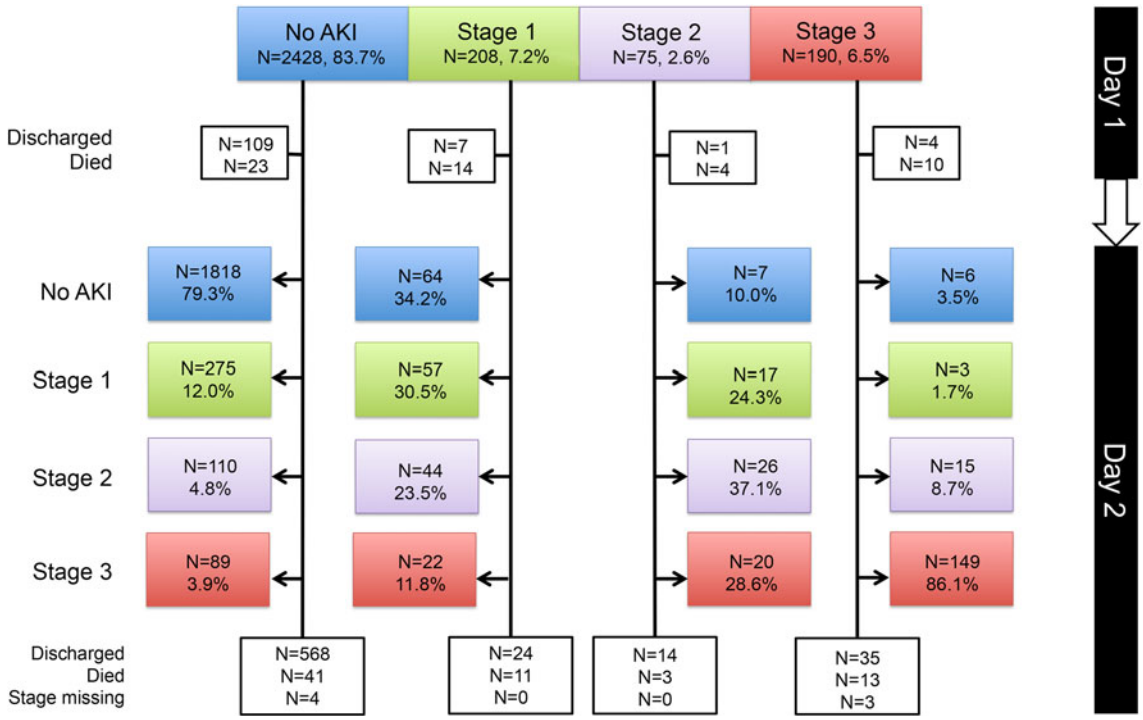

Fig. 2 Progression of acute kidney injury (AKI) from admission (day 1) to day 2 in all patients ($N = 2{,}901$)

without AKI is presented in Fig. 3. In a logistic regression analysis AKI was independently associated with increased 90-day mortality [ORs (95 % CI) 1.71 (1.31–2.23), 1.78 (1.26–2.51), 1.71 (1.28–2.29) for AKIN stages 1–3, respectively]. In this analysis non-operative admission (OR 2.21), age (OR 1.04), and highest lactate from the first 24 h of admission (OR 1.17) were also independently associated with 90-day mortality.

Discussion

In this study we found that the population-based incidence of ICU-treated AKI was 746 pmp/year. The incidence of AKI in adult ICU patients in Finland was 39 %. Independent factors associated with AKI were pre-ICU hypovolaemia, pre-ICU use of diuretics and colloids, and chronic kidney disease. The 90-day mortality for AKI patients was 34 %.

To the best of our knowledge no previous study has evaluated the population-based incidence of ICU-treated AKI using a prospective, multi-centre, nationwide study design and standardized complete RIFLE, AKIN or KDIGO criteria. A retrospective study from one county area (population 124,277) from the USA reported a very high incidence of ICU-treated AKI (2,900 pmp/year) compared to our study [19]. In another retrospective study from one region in Scotland (population 523,390) the incidence of AKI was reported as 2,147 pmp/year [20]. Results from recent epidemiological AKI studies using original RIFLE or AKIN criteria are not uniform and report AKI incidences from 10 to 70 % among ICU patients [7, 9, 10, 12, 21, 22]. Variations in AKI definitions and study populations may partly explain the differences. Our results are comparable to two large retrospective studies using the AKIN criteria that reported AKI incidences of 37.1 % [7] and 28.5 % [12]. We found a higher incidence of stage 3 AKI (14 %), which may be explained by the fact that RRT data were not completely available in the other two large studies [7, 12]. The number of RRT patients in our study was in close agreement with a previous retrospective report from Finland [23].

This is the first AKI incidence study evaluation the newly published KDIGO criteria. At the time of this study the KDIGO criteria were not yet available. However, we were able to retrospectively use the KDIGO criteria. In this population, our 'modified AKIN' and the KDIGO criteria resulted in exactly the same classification of the patients to different AKI stages.

Coincidental risk factors and chronic comorbidities such as old age, hypovolaemia, diabetes, heart or lung disease are considered to predispose patients to AKI [5]. In agreement, in our study the AKI patients were older, and had more baseline comorbidities, and medications (Table 1). Hypertension, arteriosclerosis, diabetes and chronic kidney disease were frequent in AKI patients. Over one-third of the AKI patients used diuretics, angiotensin-converting enzyme inhibitors or angiotensin II receptor blockers, or statins, were hypovolaemic, had severe sepsis, or were hypotensive prior to AKI onset (Table 3). In this respect two other multi-centre, prospective studies on AKI have had comparable findings [21, 22]. Before ICU admission a larger proportion of AKI patients had received diuretics and colloids (starch and gelatin) compared to patients without AKI. However, during ICU treatment a smaller proportion of AKI patients received diuretics and the use of colloids did not differ between patients with and without AKI. Of the patients that received colloids before ICU admission half received gelatin, 40 % received starch and less then 10 % received both.

The hospital mortality of AKI patients (26 %) corroborated with that of a previous large multi-centre study (25 %) [7]. Hospital mortality in different AKIN stages 1–3 (20, 26 and 32 %, respectively) were comparable to a previous Finnish retrospective study [24]. In a study by Joannidis et al. [12] the reported hospital mortality for AKIN stage 1 (34.5 %), stage 2 (29.0 %) and stage 3 (41.2 %) were higher compared to our study. Regrettably, no studies reporting 90-day mortality of ICU-treated AKI patients (34 % in this study) classified according to RIFLE or AKIN exist.

Our study has some limitations. First, we focused our study on ICU-treated AKI. Concomitantly, the number of AKI patients treated in ordinary wards is plausibly substantial. Second, we decided to screen patients for AKI for 5 days and were therefore unable to register the late AKIs. However, in this study 83 % of the AKI patients developed AKI on day 1 or day 2. Third, we could obtain actual baseline serum/plasma Cr values for 64 % of patients and estimated those lacking a baseline Cr with MDRD calculation, as suggested [25]. However, the MDRD method may lead to a slight over- or underestimation of AKI [26, 27]. Fourth, owing to limited data we were not able to analyse the independent association of starch/gelatin with risk of AKI. Finally, we excluded elective admissions with an expected ICU LOS of less than 1 day, but we included those patients if their ICU stay exceeded 24 h. The strength of our study is the multicentre, prospective design covering the majority of the adult population in Finland. Additionally, we were able to include the 90-day mortality data and, thus, to present the actual long-term outcome of the AKI patients.

In this nationwide prospective study we found that the incidence of AKI in Finnish ICUs was in close agreement with the few other studies using comparable AKI criteria. The hospital mortality (26 %) of critically ill patients with AKI was comparable or lower than in other studies. Of note, two-thirds of the AKI patients were still alive at day 90.

Table 3 Risk factors associated with acute kidney injury (AKI)

	Before ICU admission			Before day 5		
	NO AKI ($N = 1{,}760$)	AKI ($N = 1{,}141$)	P	NO AKI ($N = 1{,}760$)	AKI ($N = 1{,}141$)	P
Severe sepsis	299/1,760 (17.0)	367/1,141 (32.2)	<0.001	365/1,760 (20.7)	388/1,141 (34.0)	<0.001
DIC	16/1,750 (0.9)	41/1,135 (3.6)	<0.001	29/1,759 (1.6)	52/1,138 (4.6)	<0.001
Hypotension	303/1,744 (17.4)	395/1,117 (35.4)	<0.001	303/1,744 (17.4)	395/1,117 (35.4)	<0.001
Rhabdomyolysis	37/1,756 (2.1)	40/1,138 (3.5)	0.015	56/1,760 (3.2)	41/1,139 (3.6)	0.307
Hypovolaemia	404/1,754 (23.0)	467/1,127 (41.4)	<0.001	404/1,754 (23.0)	467/1,127 (41.4)	<0.001
Resuscitation	169/9.6 (9.6)	150/1,138 (13.2)	0.002	194/1,760 (11.0)	155/1,138 (13.6)	0.021
Low cardiac output	56/1,758 (3.2)	81/1,138 (7.1)	<0.001	56/1,758 (3.2)	81/1,138 (7.1)	<0.001
Massive transfusion	46/1,760 (2.6)	47/1,141 (4.1)	0.017	46/1,760 (2.6)	47/1,141 (4.1)	0.017
Emergency surgery	366/1,758 (20.8)	279/1,139 (24.5)	0.012	504/1,758 (28.7)	323/1,139 (28.4)	0.445
Radiocontrast dye	454/1,751 (25.9)	247/1,134 (21.8)	0.006	550/1,759 (31.3)	273/1,137 (24.0)	<0.001
Peptidoglycan antibiotics	131/1,757 (7.5)	102/1,136 (9.0)	0.081	184/1,760 (10.5)	119/1,139 (10.4)	0.524
ACE inhibitor or ARB	388/1,733 (22.4)	326/1,108 (29.4)	<0.001	468/1,760 (26.6)	340/1,127 (30.2)	0.021
NSAID	152/1,684 (9.0)	109/1,084 (10.1)	0.201	226/1,757 (12.9)	120/1,125 (10.7)	0.043
Diuretics	428/1,713 (25.0)	436/1,104 (39.5)	<0.001	1,063/1,760 (60.4)	597/1,122 (53.2)	<0.001
Colloids (gelatin or starch)	439/1,634 (26.9)	409/1,086 (37.7)	<0.001	774/1,760 (44.0)	513/1,114 (46.1)	0.147

Values are expressed as count (percentage)
DIC disseminated intravascular coagulation, *Hypotension* systolic blood pressure <90 mmHg for 1 h, *Rhabdomyolysis* CK >5,000 U/l or myoglobin >5,000 µg/l, *Hypovolaemia* by clinicians' judgement, *Resuscitation* haemodynamic collapse requiring CPR, defibrillation or administration of adrenalin, *Low cardiac output* inadequate systolic function + hypotension + signs of tissue hypoxia, *Massive transfusion* transfusion of more than ten red blood cell units, *ACE* angiotensin-converting enzyme, *ARB* angiotensin II receptor blocker, *NSAID* non-steroidal anti-inflammatory drug

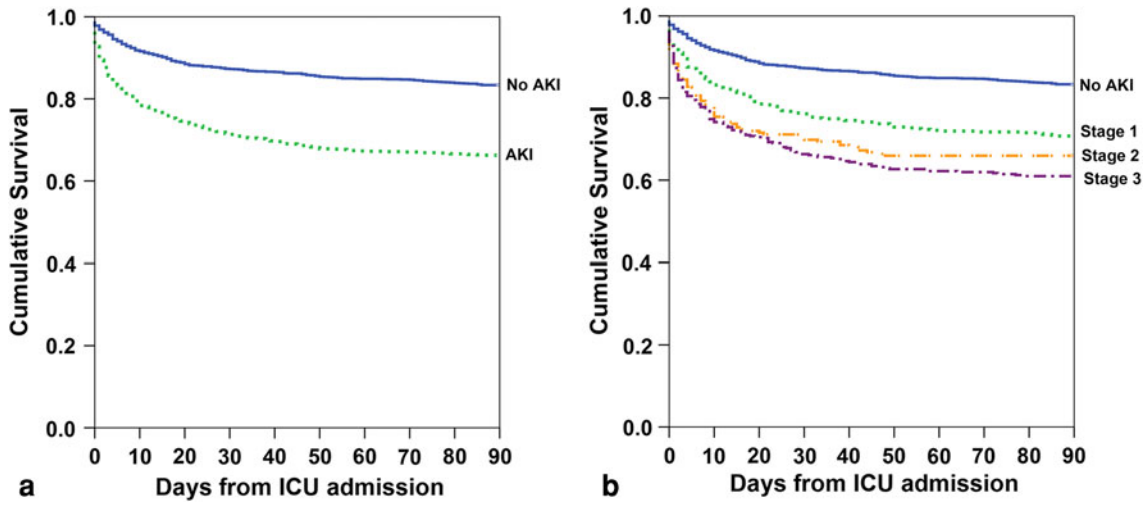

Fig. 3 Kaplan–Meier 90-day survival curves. **a** Patients with and without acute kidney injury (AKI). **b** Patients without AKI and patients with different Acute Kidney Injury Network (AKIN)/Kidney Disease: Improving Global Outcomes (KDIGO) stages of AKI

Acknowledgments We thank Tieto Healthcare and Welfare Ltd for database management. We received Clinical Research funding (EVO) TYH 2010109/2011210 and T102010070 from Helsinki University Hospital and grants from the Finnish Society of Intensive Care, the Academy of Finland and the Juselius Foundation. SN has received a grant from the Finnish Society of Anaesthesiologists.

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