British Journal of Anaesthesia **110** (1): 13–20 (2013)
Advance Access publication 20 November 2012 · doi:10.1093/bja/aes401

BJA

Patients with end-stage renal disease admitted to the intensive care unit: systematic review

N. Arulkumaran[1]*, N. M. P. Annear[2] and M. Singer[1]

[1] Bloomsbury Institute of Intensive Care Medicine, University College London, Cruciform Building, Gower Street, London WC1E 6BT, UK
[2] Division of Medicine, University College London, Rayne Building, University Street, London WC1E 6JF, UK

* Corresponding author. E-mail: nish_arul@yahoo.com

Editor's key points

- This systematic review addresses the issue of outcome of patients with end-stage renal disease (ESRD) admitted to the intensive care unit (ICU).
- In the 16 identified studies, cardiovascular disease and sepsis accounted for the majority of the admissions.
- Compared to patients with acute kidney injury requiring renal replacement therapy, patients with chronic ESRD had a better ICU and hospital survival.
- Importantly, this review suggests that appropriately selected patients with ESRD frequently benefit from ICU admission.

Summary. The number of patients with end-stage renal disease (ESRD) is increasing worldwide, with a growing demand on healthcare services. A systematic review of the literature was performed to determine the requirement for intensive care unit (ICU) services, reasons for admission, predictors of mortality, and short- and long-term outcomes of ESRD patients admitted to ICU. Sixteen studies were identified, comprising 6591 ICU admissions. Cardiovascular disease and sepsis accounted for the majority of admissions. Acute illness severity scores tend to overestimate mortality among ESRD patients. Critical illness associated with acute kidney injury (AKI) requiring renal replacement therapy (RRT) is associated with significantly higher hospital mortality compared with ESRD patients admitted to the ICU [odds ratio (OR) 3.9; 3.5–4.4; $P<0.0001$]. However, hospital mortality of ESRD patients is less favourable compared with matched patients with mild AKI (OR 1.5; 1.4–1.6; $P<0.0001$). Although the mortality rate remains high shortly after hospital discharge, the duration of increased mortality risk is unclear. Patients with ESRD frequently benefit from ICU admission, despite chronic co-morbidity. Further studies are required to modify and validate existing illness severity scores for ESRD patients admitted to the ICU, and to establish the duration of increased mortality risk after discharge from ICU.

Keywords: intensive care; kidney, failure; renal

The incidence and prevalence of chronic kidney disease (CKD) and end-stage renal disease (ESRD) are increasing appreciably,[1 2] reflecting an increased prevalence of hypertension, type 2 diabetes mellitus, and an ageing population.[3] The prevalence of CKD in the USA is ~13% among the adult population,[4] while the incidence of patients reaching ESRD requiring renal replacement therapy (RRT) is 347.6 per million population per year.[1] Patients with ESRD (defined as having an estimated glomerular filtration rate of <15 ml min^{-1} 1.73 m^{-2}) have significant co-morbidities and a greater mortality risk compared with an age-matched cohort. The relative risk for all-cause mortality, cardiovascular events, and hospitalization rates are 5.9, 3.4, and 3.1, respectively, relative to patients with normal renal function.[5] Morbidity and mortality are predominantly related to cardiovascular disease and sepsis.[1 6]

Despite the increase in numbers of patients with ESRD and its associated complications, better provision of care for these patients is associated with improved mortality rates.[3] Consequently, a greater expectation of survival after critical illness drives an ever-increasing demand for ICU facilities.[7] Illness severity scores have not been specifically evaluated to predict outcome in ESRD patients, since most scores allocate points for physiological and laboratory data that are usually outside the normal range in stable ESRD patients. Establishing the requirement for ICU services, predictors of mortality, and the short- and long- term outcomes among the ESRD population is therefore important.

We reviewed the literature to determine the epidemiology of patients with ESRD admitted to ICU, causes for admission, factors associated with mortality, and short- and long-term outcomes. The hospital mortality of ESRD patients was compared with patients with AKI requiring RRT and with patients with 'mild renal injury' admitted to the ICU.

Methods

We performed a review of the literature using the National Centre for Biotechnology Information (NCBI) PubMed database using a combination of medical subject headings (MeSH), title, and abstract keywords. The search terms used were: 'end stage renal failure' or 'end stage renal disease' or 'dialysis' and 'intensive care' or 'critical care'. Reviews, editorials, and individual case reports were excluded, as were

publications based on the same data sets. CKD is defined by the National Kidney Foundation Disease Outcomes Quality Initiative (KDOQI) guidelines.[8] Patients with an estimated GFR of <15 ml min^{-1} 1.73 m^{-2} are defined as having stage 5 CKD. We defined ESRD as patients with stage 5 CKD receiving chronic dialysis. Patients with stage 5 CKD not receiving dialysis were excluded. All other publications were included, irrespective of size, journal, or country of origin.

Epidemiology, causes for ICU admission, illness severity scores on ICU admission, and short- and long-term outcomes were assessed where reported. The χ^2 tests were used to calculate the differences in survival between the groups, with data reported as odds ratio (OR; confidence intervals; *P*-value). Graphpad Prism Version 5.0 (GraphPad Software, Inc., CA, USA) was used to perform statistical analyses.

Results

Study selection

A total of 18 studies were identified. Two studies were excluded as data were extracted from the same ESRD population reported in other studies. The study by O'Brien and colleagues[9] was excluded as it includes data extracted from the UK Intensive Care National Audit and Research Centre (ICNARC) database, as reported by Hutchison and colleagues.[10] Furthermore, the study by O'Brien and colleagues focused primarily on patients with cirrhosis. Similarly, studies by Sood and colleagues[11] and Strijack and colleagues[12] included data from the same patient cohort. Since the study by Sood and colleagues was an analysis of long-term outcomes from the same patient cohort, it was excluded from analysis. However, results from the two excluded studies have been included in our discussion.

Epidemiology

The 16 studies included in this analysis describe a total of 6591 ICU admissions for patients with ESRD[10 12–26] conducted in nine different countries (Table 1). Two were prospective case–control studies, four were prospective cohort studies, and the remaining 10 were retrospective cohort studies. Sample sizes varied from 28 to 3420 patients, while study periods ranged between 30 days and 10 yr. Where specified, the majority of patients were receiving haemodialysis (HD) rather than peritoneal dialysis (PD) as their mode of long-term RRT. A total of eight studies specified the mode of chronic RRT.[17–20 22–24 26] Out of 580 patients, 71 (12%) were receiving PD and 509 (88%) were receiving HD. The mean patient ages were between 44 and 66 yr.

ICU bed requirements were significantly greater among ESRD patients than the general population. A study of 476 ESRD patients followed over 7 yr reported that 20% required ICU admission.[17] Compared with the general population, the risk of requiring ICU admission and RRT in the ESRD population was four-fold greater in the largest study which reviewed 276 731 ICU admissions between 1995 and 2004, 1.3% (3420) of whom were identified as having ESRD.[10] This represents an ICU utilization rate of six admissions (32 bed-days) per 100 dialysis patient-years.

Causes for ICU admission

The most common causes for ICU admission were cardiogenic pulmonary oedema and sepsis, accounting for up to 24% and 20.5% of cases, respectively.[10 12 13 19 20 22–24] A review of 102 chronic dialysis patients admitted to the ICU with acute pulmonary oedema revealed common triggers included acute pulmonary infection, excessive inter-dialytic weight gain, inappropriate dry weight prescription, and primary cardiac events.[18] A further important reason for admission related to surgical diagnoses, ranging 9–27% of admissions.

Outcome predictors

Compared with ICU patients without acute kidney injury (AKI), illness severity scores were consistently higher among patients with ESRD.[10 12 13 16 17 20] However, when compared with patients with AKI requiring RRT, illness severity scores were either similar[22 24] or lower among those with ESRD[12 13] (Table 2). Factors predicting poor outcome include age,[10 14 22 23] non-renal organ failure,[14 19 20 22 23] and admission for a 'medical' as opposed to a surgical reason.[13 15]

The acute physiology and chronic health evaluation illness severity scores (APACHE II and APACHE III scoring systems), simplified acute physiology score (SAPS II), and sequential organ failure assessment (SOFA) score were used in 12, two, and two studies, respectively. Seven of the 10 studies using APACHE II had a higher predicted than actual ICU mortality rate.[12 13 18 19 23–25] In six of these reports, this value exceeded the reported mortality by $>10\%$ [12 13 18 19 23 25] Similarly, actual hospital mortality was lower than that predicted in both studies using APACHE III scores,[16 17] and one of the two studies using SAPS II scores.[22] The SOFA score accurately predicted mortality in one study[18] and under-predicted mortality in another.[21]

Short-term outcome

The reported ICU mortality of ESRD patients ranged from 9% to 44% (Table 2). The mean ICU mortality was 21.4% and hospital mortality 34.5%. Six studies reported hospital mortality rates of ESRD patients and patients with AKI requiring RRT,[12 13 21 22 24 25] including 3216 patients with AKI requiring RRT and 2182 patients with ESRD. There was a significantly increased risk of hospital mortality among patients with AKI requiring RRT (55%) compared with ESRD patients (24%) (OR 3.9; 3.5–4.4; $P<0.0001$). Similarly, the 90 day mortality among patients with AKI requiring RRT was significantly higher than ESRD patients, which was 56% and 38%, respectively (OR 2.1; 1.4–3.3; $P=0.0007$).[13 26]

Although AKI is commonly stratified using the RIFLE[27] or AKIN[28] criteria, many studies included in this systematic review were published before the use of the RIFLE or AKIN