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Incident haemodialysis and outcomes in the Top End of Australia

Jaquelyne T. Hughes[1,2,7] BMed, FRACP, PhD, Senior Research Fellow, Consultant Nephrologist

Sandawana W. Majoni[1,2,3] MBChB, MRCP, FRACP, MMedStats, MClinicalMed, FRCP, Honorary Clinical Fellow, Consultant Nephrologist, Senior Lecturer

Federica Barzi[1] MSC, PhD, Senior Biostatistician

Tegan M. Harris[1] PhD, Senior Research Officer

Selina Signal[2] Grad.Cert-Renal, Clinical Nurse Manager – Renal Unit

Gwendoline Lowah[2] RN, Registered Nurse L3 Acute Dialysis Unit

Jola Kapojos[2] FRACP, PhD, Renal Fellow

Asanga Abeyaratne[2] FRACP, Consultant Nephrologist

Madhivanan Sundaram[2] MBBS, MD, DM, DNB, FRACP, Consultant Nephrologist

Paul Goldrick[4] FCICM, FANZCA, FFARCSI, Director

Sarah L. Jones[4] MRCP, DICM, FCICM, Intensive Care Specialist

Robert McFarlane[5] MSC, Network Supervising Scientist

Lewis T. Campbell[1,3,4] MB, ChB, Bsc(Hons), FCICM, FRCP(Edin), Honorary Clinical Fellow, Senior Lecturer, Senior Staff Specialist

Dianne Stephens[3,4,6] OAM, MBBS, FANZCA, FCICM, FCHSM, Medical Director

Alan Cass[1] MBBS, BA, FRACP, PhD, FAHMS, Director

[1]Menzies School of Health Research, Charles Darwin University, PO Box 41096, Casuarina, NT 0811, Australia. Email: william.majoni@nt.gov.au; federica.barzi@nt.gov.au; Tegan.Harris@menzies.edu.au; Lewis.Campbell@nt.gov.au; alan.cass@menzies.edu.au

[2]Department of Nephrology, Division of Medicine, Royal Darwin Hospital, PO Box 41326, Casuarina, NT 0811, Australia. Email: Selina.Signal@nt.gov.au; Gwendoline.Lowah@nt.gov.au; Jola.Kapojos@sa.gov.au; Asanga.Abeyaratne@nt.gov.au; Madhivanan.Sundaram@nt.gov.au

[3]Northern Territory Clinical School, Flinders University, Darwin, NT 0811, Australia. Email: Dianne.Stephens@nt.gov.au

[4]Intensive Care Unit, Royal Darwin Hospital, PO Box 40596, Casuarina, NT 0811, Australia. Email: Paul.Goldrick@nt.gov.au; SarahL.Jones@nt.gov.au

[5]Chemical Pathology, Territory Pathology, Department of Health, PO Box 41326, Casuarina, NT 0811, Australia. Email: Robert.McFarlane@nt.gov.au

[6]National Critical Care and Trauma Response Centre, Royal Darwin Hospital, Darwin, NT 0810, Australia.

[7]Corresponding author. Email: Jaqui.hughes@menzies.edu.au

Abstract

Objective. The Northern Territory has the highest incidence of haemodialysis care for end-stage kidney disease in Australia. Although acute kidney injury (AKI) is a recognised risk for chronic kidney disease (CKD), the effect of AKI causing incident haemodialysis ($_{i}$HD) is unknown. Audits identifying antecedents of $_{i}$HD may inform health service planning. Thus, the aims of this study were to describe: (1) the development of an $_{i}$HD recording system involving patients with AKI and CKD; and (2) the incidence, patient characteristics and mortality for patients with dialysis-requiring AKI.

Methods. A retrospective data linkage study was conducted using eight clinical and administrative datasets of adults receiving $_{i}$HD during the period from July 2011 to December 2012 within a major northern Australian hospital for AKI

without CKD (AKI), AKI in people with pre-existing CKD (AKI/CKD) and CKD (without AKI). The time to death was identified by the Northern Territory Register of deaths.

Results. In all, 121 iHD treatments were provided for the cohort, whose mean age was 51.5 years with 53.7% female, 68.6% Aboriginal ethnicity and 46.3% with diabetes. iHD was provided for AKI (23.1%), AKI/CKD (47.1%) and CKD (29.8%). The 90-day mortality rate was 25.6% (AKI 39.3%, AKI/CKD 22.8%, CKD 19.4%). The 3-year mortality rate was 45.5% (AKI 53.6%, AKI/CKD 22.8%, CKD 19.4%). The time between requesting data from custodians and receipt of data ranged from 15 to 1046 days.

Conclusion. AKI in people with pre-existing CKD was a common cause of iHD. Health service planning and community health may benefit from AKI prevention strategies and the implementation of sustainable and permanent linkages with the datasets used to monitor prospective incident haemodialysis.

What is known about the topic? AKI is a risk factor for CKD. The Northern Territory has the highest national incidence rates of dialysis-dependent end-stage kidney disease, but has no audit tool describing outcomes of dialysis-requiring AKI.
What does this paper add? We audited all iHD and showed 25.6% mortality within the first 90 days of iHD and 45.5% overall mortality at 3 years. AKI in people with pre-existing CKD caused 47.1% of iHD.
What are the implications for practitioners? Health service planning and community health may benefit from AKI prevention strategies and the implementation of sustainable and permanent linkages with the datasets used to monitor prospective incident haemodialysis.

Additional keywords: acute kidney injury, end-stage kidney disease, health services, Indigenous Australian.

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Introduction

Acute kidney injury (AKI) is a clinical syndrome marked by an abrupt decline in kidney function due to altered pathophysiological pathways.[1] Severe AKI that requires dialysis (Stage III AKI) is an internationally recognised marker of increased mortality, with some long-term survivors requiring maintenance dialysis.[2,3] Chronic kidney disease (CKD) is defined by structural kidney damage or sustained loss of kidney function (at least 3 months) and marked by reduced glomerular filtration rate and/or albuminuria.[4] Renal replacement therapy (RRT), using maintenance dialysis or kidney transplantation, is required to support metabolic functions for patients with Stage 5 CKD and uraemic symptoms.

Risk markers for CKD include older age, hypertension, diabetes, disadvantage and being part of an Indigenous population. In people with acute illness, the following factors increase the risk of developing AKI: age >65 years, CKD, past history of AKI, coexisting illness, hypovolaemia, sepsis, use of iodinated contrast agents within the previous week, current or recent nephrotoxic agents and being in the perioperative period. Although susceptibility factors for AKI have also included ethnicity (Black race), a multiethnic Canadian study of AKI and critical illness found that First Nation race was not predictive of higher mortality.[5] Auditing the frequency and cause of Stage III AKI events in populations with endemic CKD may generate hypotheses regarding factors leading to rapid kidney injury progression. However, there are few studies that describe the incidence of dialysis requiring AKI or patient outcomes in Indigenous populations living in CKD endemic areas, which could inform the development of interventions to maintain health and preserve kidney function.

Australia has one of the highest prevalence rates of CKD internationally.[6] The Australia and New Zealand Dialysis and Transplant Registry (ANZDATA) is the main resource used nationally for renal service and dialysis planning. ANZDATA documents patients receiving chronic RRT who survive at least 90 days after incident haemodialysis (iHD). ANZDATA does not require information recording the period between incident dialysis and the first 90 days, and even then only records maintenance dialysis.[7] During 2011, ANZDATA reported an Australian incidence rate for maintenance haemodialysis of 83 per million population,[8] where Indigenous Australians had a 4.5-fold higher burden than non-Indigenous Australians (337 vs 75 per million population).[8] Although ANZDATA recorded an incidence rate for chronic maintenance haemodialysis in the Northern Territory (NT) of 523 per million population,[8] there was no auditable recording system of CKD trajectory before a client's first record within ANZDATA.[9] Furthermore, there was no recording system for antecedents of and outcomes following dialysis-requiring AKI. Therefore, we sought to define the feasibility of creating a recording system to define the characteristics and outcomes of patients admitted for dialysis-requiring AKI. We hypothesised that dialysis-requiring AKI resulted in a permanent loss of kidney function, which contributed to the high burden of end-stage kidney disease (ESKD) in the NT. The aims of this study were to describe the development of an iHD recording system (iHD-RS), and to describe the incidence, patient characteristics and mortality (at 90 days and 3 years) of patients with severe dialysis-requiring AKI. This research question aligns with Indigenous patient priorities for clear and useful information about kidney health and the regionally specific expected health journey for people with CKD.[10] The audit was supported at the outset by the Top-End Renal Patient Advisory and Advocacy Committee, and supports Indigenous data custodian principles relating to Aboriginal kidney health data.[11,12]

Methods

We designed a data linkage study to enable an audit of health service use for iHD. The research proposal was supported by the

Top-End Renal Patient Advisory and Advocacy Committee, and was approved with waiver of individual consent by the NT Department of Health and Menzies School of Health Research Human Research Ethics Committee, including the Aboriginal Ethics Subcommittee.

Inclusion criteria

Adults (age >18 years) who received an ¡HD treatment at the only hospital providing ¡HD in the region, in either the dialysis unit or intensive care unit (ICU), were included in the study. Kidney impairment for admissions involving haemodialysis was recorded as AKI, AKI with pre-existing CKD (AKI/CKD) or CKD (without AKI). We included the earliest recording period of ¡HD within both units (July 2011). Patients with prevalent ESKD care or previously registered in ANZDATA were excluded.[13]

Data linkage

We developed a ground-up recording system, starting with the ICU dataset (Australian Outcomes Research Tool for Intensive Care (AORTIC)), the dialysis unit diary and the clinical record. In total, we secured access to eight key datasets to define the cohort, describe the availability and results of kidney function testing and serum creatinine trajectory leading up to ¡HD treatment and describe the cause of admission. We recorded the duration (in days) between the data access request and receipt of data for each dataset. Linkage of datasets was managed independently of the research team using a unique identifying code and secure data portal.

The dialysis unit diary, AORTIC database and ANZDATA defined the cohort of interest and location at ¡HD, community- and hospital-based pathology confirmed pre-existing kidney function, the NT Department of Health Emergency Department dataset defined the location of residence (postcode or locality) preceding hospital presentation and the admitted patient care, medical chart review and AORTIC datasets defined the circumstances of the hospital admission.

Measures

Kidney impairment categories were defined from the admitted patient cohort admission diagnoses, coded into International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM) diagnostic codes. AKI was defined by ICD-10-AM code as either acute nephritic syndrome (N00), acute tubulointerstitial nephritis (N10) or acute kidney failure (N17).[14] All AKI was classified as Stage III[15] Since all patients required intermittent or continuous haemodialysis therapy. CKD was defined by ICD-10-AM codes E10.2, E11.2, E13.2, E14.2, I12, I13, I15.0, I15.1, N00–N09, N11, N12, N14, N15, N16, N18, N19, N25–N28, N39.1, N39.2, Q60–Q63, T82.4, T86.1, Z49.0, Z94.0 and Z99.2.[14] Diabetes was defined by ICD-10-AM codes E10–E14 and 04*.

Principal causes of admission, including infection and cardiovascular diseases, were identified.[2] Suburb or postcode provided before admission was converted to an Accessibility/Remoteness Index of Australia (ARIA) 2011+ score.[16] In this analysis, 'remote' and 'very-remote' were reported as a single category.

Baseline kidney function was reported using the estimated glomerular filtration rate (eGFR) reported by the Chronic Kidney Disease Epidemiology Collaborative (CKD-EPI) formula without correction for African American peoples,[17] using serum creatinine within 90 days and not less than 8 days before admission.[15] Patients with ¡HD in the ICU were also scored using an Acute Physiology and Chronic Health Evaluation (APACHE) III score, where higher values predict hospital mortality.[18]

Outcomes included survival at 90 days after the date of hospital admission with and without maintenance RRT (confirmed by ANZDATA), and survival at a minimum of 3 years of follow-up[2] (or censored to 31 December 2015). The date and causes of mortality were provided by the NT Register of Deaths, encoded to ICD-10-AM and subclassified into five categories (infection, cardiovascular, malignancy, metabolic and other).[2]

Statistical analyses

Data are reported as the mean ± s.d. for continuous, normally distributed variables and as the median and interquartile range (IQR) for non-normally distributed variables. Categorical variables are described as a percentage. Differences between kidney impairment groups were described by analysis of variance (ANOVA) for continuous variables and the Chi-squared statistic for categorical variables. Differences in survival were described by Kaplan–Meier survival estimates. Analyses were performed using Stata 14 (Stata Corp., College Station, TX, USA).

Results

Developing the ¡HD-RS

The ¡HD-RS was created through linkage of data from eight datasets (Table 1). The time between the request for data and receipt of data ranged from 15 to 1046 days. Confirmation of data sharing agreements was a requirement before agreement to link to the admitted patient cohort and emergency presentation datasets (which was received on Day 1046). The data access request for community pathology (for serum creatinine) was abandoned after 392 days, and was subsequently accessed from an alternative source (NT Department of Health Data Warehouse).

Cohort characteristics

During the 18-month observation period, 121 adults received an ¡HD treatment (6.7 patients per month; Table 2). The mean age of patients was 51.5 years (range 18.5–84.3 years), 53.7% were female, 68.6% were Aboriginal, 46.3% of patients had diabetes and 65.3% were living in remote or very remote localities relative to the admitting hospital before admission. In this cohort, 59.5% had an eGFR test recorded at all three time points in the previous 2 years (admission, 90 days prior and 2 years prior), including 35.7% in the AKI group, 63.2% in the AKI/CKD group and 72.2% in the CKD group.

Admissions

The median hospital length of stay for all patients was 11 days (IQR 5–23 days). AKI/CKD was the most common kidney impairment category (57/121; 47.1%; Table 2), followed by CKD (36/121; 29.8%) and AKI (28/121; 23.1%). Thirty-three of 36 patients with CKD were known to the renal service before ¡HD.

The median length of stay in hospital was 15 days for AKI/CKD, 9.5 days for AKI and 7 days for CKD ($P = 0.001$). ¡HD was provided in the ICU setting for 54.5% of patients. Six patients with CKD had ¡HD provided in the ICU (Table 2). Diagnoses of

Table 1. Development of the incident haemodialysis recording system

ACR, albumin : creatinine ratio; AKI, acute kidney injury; ANZDATA, Australia and New Zealand Dialysis and Transplantation Registry; AORTIC, Australian Outcomes Research Tool for Intensive Care; CKD, chronic kidney disease; ED, emergency department; ICD-10-AM; International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification; ICU, intensive care unit; iHD, incident haemodialysis; NT, Northern Territory; RRT, renal replacement therapy

Dataset	Data Custodian	Key variable(s)	Key reason for variables	Time to receive data (days)
AORTIC database	ICU, Royal Darwin Hospital	Dates (admission and discharge), referral source (ED, ward, other), dialysis provided, vital status of discharge, discharge destination	Define the cohort	75
Dialysis unit paper-based diary	Top-End Renal Services	Date and reason for initiation (AKI, CKD)		54
Medical Chart review	Top-End Health Services	Comorbid conditions, dates (admission and discharge), dialysis access stats at initiation		15
ANZDATA	ANZDATA	Date of dialysis initiation, vital status and modality at 3 years	Individuals who required (prevalent) chronic RRT at first presentation in the audit were excluded; chronic RRT use at 90 days and 3 years was confirmed	133
NT Register of Deaths	NT Births, Deaths and Marriages	Date and cause of death	Time to death and cause of death were confirmed	21
Hospital-based pathology	Territory Pathology	Serum creatinine, urinary ACR and date of result(s)	Both hospital and community pathology would provide the best coverage of kidney function measures in patients before iHD	430 days; the data transfer agreement was secured at 28 days, but we delayed data transfer until the day we secured the community-based pathology data agreement
Community-based pathology	Private pathology provider		Serum creatinine concentration was used to determine pre-existing CKD monitoring and kidney function before iHD	Data agreement not secured after 392 days
Community-based pathology	NT Department of Health Data Warehouse			137
Admitted patient care	NT Department of Health	Admission episode number, admission diagnoses as ICD-10-AM diagnostic codes, admission date, discharge date	Principal and additional hospital diagnoses	1046 days (noting 115 days to transfer data after agreement)
ED	NT Department of Health	Dates of ED presentation, referral source (community, air ambulance, other hospital, other), suburb and postcode of usual address, date of discharge and destination	Residential region before hospital admission	

Table 2. Patient characteristics stratified by kidney impairment group

Unless indicated otherwise, data are given as the mean ± s.d., *n* (%) or median [interquartile range]. Baseline creatinine and estimated glomerular filtration rate (eGFR) were results collected <90 and >8 days before admission. AKI, acute kidney injury; AKI/CKD, AKI in people with pre-existing chronic kidney disease (CKD); APACHE, Acute Physiology and Chronic Health Evaluation; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay

	AKI	CKD	AKI/CKD	*P*-value
	28 (23.1)	36 (29.8)	57 (47.1)	
Age	46.5 ± 14.1	53.8 ± 11.9	52.5 ± 12.7	0.06
Female	18 (64.3)	16 (44.4)	31 (54.4)	0.29
Aboriginal	15 (53.6)	29 (80.5)	39 (68.4)	0.07
Remote-Very remote	14 (50.0)	28 (77.7)	37 (64.9)	0.07
Baseline eGFR (mL min^{-1} 1.73 m^{-2})				<0.0001
No. patients	12	24	37	
Median [IQR]	110 [79–115]	5 [4–8]	22 [10–50]	
Serum creatinine ratio[A]				0.0002
No. patients	12	24	37	
Median [IQR]	2.5 [1.8–4.6]	1.1 [0.9–1.5]	1.5 [1.2–2.1]	
Diabetes as a comorbid condition	4 (14.3)	19 (52.8)	33 (57.9)	<0.001
Admission diagnoses categories[B]				
Infection	19 (67.9)	7 (19.4)	36 (63.2)	<0.001
Cardiovascular disease	9 (32.1)	4 (11.1)	16 (28.1)	0.090
Hospital LOS (days)	9.5 [5–25]	7 [2–12]	15 [8–27]	0.013
First dialysis in ICU	27 (96.3)	6 (16.7)	33 (57.9)	<0.001
ICU LOS (days)	6 [3–13]	2 [2–4]	4 [2–8]	0.033
ICU admission requiring ventilation	24 (88.9)	5 (71.4)	19 (57.6)	0.021
APACHE III score	98 ± 38	100 ± 41	87 ± 22	0.36

[A]Serum creatinine at admission relative to baseline values (where available).
[B]Admission diagnoses for infection and cardiovascular disease refers to ICD-100AM diagnostic codes for principal or additional diagnoses.

infection (either principal or additional diagnoses) were observed in 67.9%, 63.2% and 19.4% of AKI, AKI/CKD and CKD patients respectively ($P < 0.001$). In patients with AKI or AKI/CKD who had baseline serum creatinine information, there was an at least 1.5-fold increase in serum creatinine from baseline.

Overall mortality by kidney impairment category and dialysis requirement

Patients were followed up for a median of 1107 days (~3.0 years) and maximum of 1621 days (4.44 years). Fifty-five deaths were recorded (45.5% overall mortality; Fig. 1), including 25.6% who died within 90 days. Over the entire follow-up period, infection and cardiovascular diseases were the principal cause of death in 25.5% and 47.3% of cases respectfully.

Survival at 90 days (with regard to chronic maintenance dialysis)

All patients with AKI who survived 90 days (60.7%) were surviving dialysis free (Fig. 2). At 90 days, 16 of 44 (36.4%) patients with AKI/CKD and 80.5% of patients with CKD were receiving chronic maintenance RRT.

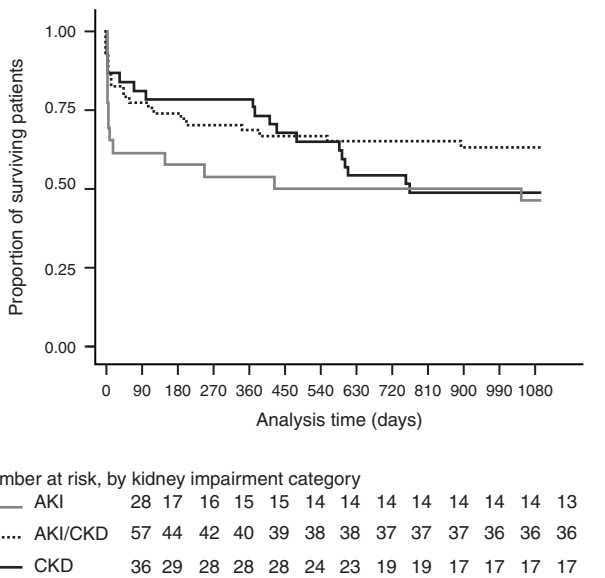

Fig. 1. Kaplan–Meier survival estimates following incident haemodialysis by kidney impairment category. AKI, acute kidney injury; AKI/CKD, AKI in people with pre-existing chronic kidney disease (CKD).

Discussion

This is the first detailed study describing the outcomes of all patients requiring iHD support in a major northern Australian hospital in a region with endemic CKD. One in four patients died within the first 90 days, with almost half who survived this initial period already undergoing chronic maintenance RRT. At 3 years, approximately half the cohort had died. The cohort was relatively young, with two-thirds of Aboriginal background and the majority who were accessing care from remote or very remote regions.

Australian clinical quality registries record health services information to document health service utilisation and to benchmark between service providers.[19] Patients, families and clinicians supported this study and the development of the

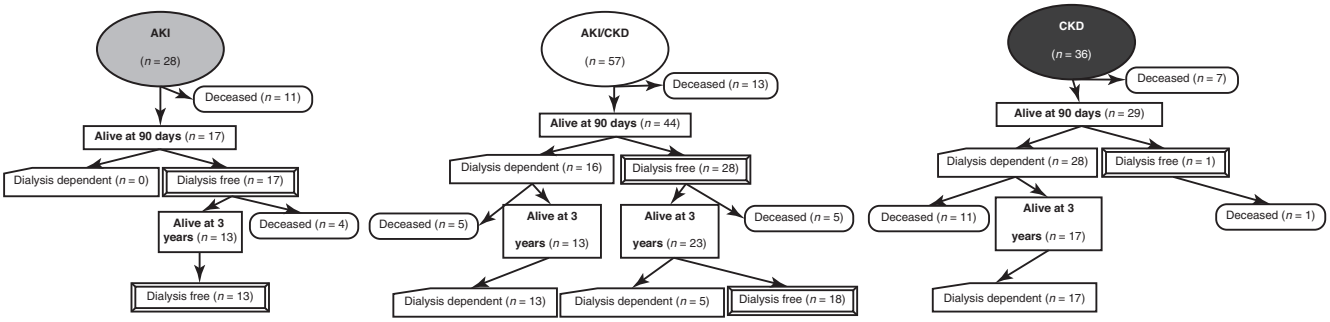

Fig. 2. Flow diagram of survival with and without renal replacement therapy at 90 days and 3 years. AKI, acute kidney injury; AKI/CKD, AKI in people with pre-existing chronic kidney disease (CKD).

$_{i}$HD-RS. First, we responded to a priority request of the Indigenous patient community for clinicians to clearly communicate region-specific information about the causes of dialysis-dependent kidney disease.[10] Second, the health service had dialysis unit capacity issues with high and unpredictable acute $_{i}$HD needs, but there was no recording system to reflect the range of service activity. This study helps explain challenges in matching resources with service demand for acute care dialysis. ANZDATA, which is the main resource used nationally for renal service and dialysis planning, documents patients receiving chronic RRT who survive at least 90 days after $_{i}$HD. In this study, we report that only one-third of patients who required $_{i}$HD were recorded in ANZDATA; two-thirds of the patients had either died before 90 days or had recovered renal function.

Critical illness at dialysis initiation

The ICU supported 57% of the cohort at $_{i}$HD, and included patients with all three kidney impairment conditions (AKI, CKD and AKI/CKD). As expected, high APACHE III scores and ventilator requirements were observed in critical illness, and the AKI group recorded the highest mortality at 90 days. Sepsis is a recognised comorbidity risk for people who have concurrent CKD,[20,21] and this audit confirmed infection as a potentially modifiable precipitant of dialysis initiation in Aboriginal people, which was not previously reported from studies involving Australian ICUs.[2]

The inception of the study was derived from clinicians and supported by patients who perceived, but needed confirmation, that AKI/CKD, particularly in the setting of sepsis, precipitated unplanned chronic maintenance RRT. The study has quantified the prognosis after $_{i}$HD, and improved the quality of local healthcare information for patients, families and health services.

Relevance to public and strategic health needs

Stage III AKI is internationally recognised as an indicator of increased mortality.[2,3] We recommend individual and health system preventative approaches for AKI, which may reduce the need for critical illness care at $_{i}$HD and delay the onset of chronic maintenance RRT. These approaches include community-wide annual kidney health screening in high-risk populations, targeted health promotion material for Indigenous communities, information and resource support for Indigenous Australian knowledge exchange health teams about the relationship between AKI and CKD, individual- and system-level approaches to improve and respond to early infections and cardiovascular health and collaborative management approaches between primary healthcare, nephrology and ICU healthcare teams.

An auditable kidney health clinical register is needed in northern Australia, and the $_{i}$HD-RS may improve the identification of high-risk patients, support clinician feedback and community-level knowledge of CKD. We show a feasible methodological approach to link data silos at the time of $_{i}$HD, which has potential benefit across multiple northern Australian sites. The observation period of 18 months, although brief, highlighted the clinical journey of patients at the time of $_{i}$HD and reported a high mortality. However, we recognise the small sample size limits the ability to ascertain the relationship of outcomes (such as explained by remote locality or Indigenous ethnicity). We always intended this study to inform the implementation of a prospective $_{i}$HD-RS, but we first needed to identify the key region-specific variables. This data linkage method was designed from the ground up given there was no auditable process available.[9,22]

One major delay to the development of the $_{i}$HD-RS was privacy concerns from the government-contracted community pathology provider. Furthermore, there was no agent who could mediate between the research team and pathology provider, which may expedite future safety and quality research projects. We have since led consultation meetings with patients living with ESKD in northern Australia to guide data use and inform clinical care recommendations that enhance and advance health for this population.[23,24]

This study was retrospective in nature, which has inherent limitations. The audit focused on $_{i}$HD, and excluded peritoneal dialysis initiation, because, like other Australian hospitals, there was no acute peritoneal dialysis program locally during the time of the study. The major strength of the research was confirming the feasibility of this approach, which can now support a prospective study of outcomes following incident dialysis for this high-risk population.

Conclusions

In this northern Australian study of characteristics and outcomes following $_{i}$HD, we report three times as many patients requiring $_{i}$HD care as were eligible for recording in the ANZDATA clinical registry. Within the overall cohort, one in four had died at 90 days, and one in two had died at 3 years. Region-specific AKI prevention strategies are recommended to preserve kidney

function in northern Australia. Defining the ¡HD-RS and strengthening relationships with data custodians will support a prospective reporting tool for AKI in this region, which has a high concurrent CKD burden.

Competing interests

All authors declare they have no competing interests.

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