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Acute kidney injury in octogenarians after heart valve replacement surgery: a study of two periods over the last decade

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Abstract

Background: Data on postoperative acute kidney injury (AKI) in octogenarians are limited. This study examines the AKI occurrence and clinical impact in octogenarians following open-heart valve replacement surgery in two periods over the last 15 years.

Methods: A total of 452 consecutive octogenarians (non–kidney transplant and non-dialysis) who underwent heart valve replacement at the Mayo Clinic during the years 2011–13 (contemporary cohort) were examined. The results were compared with a comparable 209 consecutive octogenarians in 2002–03 (past cohort). Pre-existing chronic kidney disease (CKD) was defined based on estimated glomerular filtration rate (Chronic Kidney Disease Epidemiology Collaboration formula). Outcomes included postoperative AKI defined by the Acute Kidney Injury Network (AKIN) criteria, length of hospital stay (LOS), discharge disposition and patient survival (hospital and 1 year).

Results: AKI occurrence in the contemporary cohort was lower than the past cohort (35% versus 47%, respectively, $P < 0.003$). Compared with the past cohort, the contemporary cohort had fewer known perioperative AKI risk factors (pre-existing CKD, comorbidity, heart failure, surgical duration, cross-clamp time, blood transfusion and large-volume intravenous fluids). In both periods, AKI adversely impacts mortality, LOS and discharge to a care facility.

Conclusions: Postoperative AKI in octogenarians following heart valve replacement surgery has declined over the last decade. As a result, the AKI-attributable percentage mortality has accordingly decreased. However, AKI continues to exert a heavy morbidity and mortality burden. These results are highly pertinent to practice since the octogenarian population is growing.

Key words: acute kidney injury, comparison of two time periods, octogenarians, heart valve replacement surgery, risk factors

Introduction

Acute kidney injury (AKI) following cardiac surgery is a known risk for mortality and morbidity [1]. As the population ages, more elderly patients are expected to undergo heart valve surgery [2]. Both heart valve surgery and aging are significant risk factors for AKI [3–5]. Data on the incidence and outcomes of post–valve replacement AKI in the elderly in the current era are lacking.

We recently reported the Mayo Clinic experience of the incidence and clinical significance of AKI in octogenarians following heart valve replacement surgery in the years of 2002–03 [6]. We found that 47% of octogenarians developed postoperative AKI and AKI negatively impacted patients' outcomes, including short-term and long-term mortality.

The aim of this study was to examine the occurrence and clinical impact of AKI in a contemporary cohort (years 2011–13) of octogenarians after open-heart valve replacement surgery and compare the results with those from our study of octogenarians (past cohort) a decade ago (years 2002–03).

Materials and methods

Data collection and AKI definitions

The Mayo Clinic Institutional Review Board approved the study. All participants of the study gave written consents to our institution for data analysis. Octogenarians on dialysis and those who had kidney transplant were excluded. The Charlson comorbidity index was computed [7] at the time of admission for valvular surgery. Patient survival was monitored for up to 12 months after surgery. Pre-existing chronic kidney disease (CKD) was defined based on the calculation of estimated glomerular filtration rate (eGFR) using Chronic Kidney Disease Epidemiology Collaboration formula [8] and the patient's baseline serum creatinine concentration (sCr). Baseline sCr was defined as sCr measured on the date (within 3 months) closest to the index admission and when the patient's kidney function and medical status were stable.

AKI was defined as an abrupt increase (within 48 h) in sCr $\geq$0.3 mg/dL postoperatively or a change in sCr by $\geq$1.5 times of the baseline value within 7 days after surgery. The Acute Kidney Injury Network (AKIN) urine output criteria were omitted due to imprecise urine output data. The severity of AKI was determined following the AKIN criteria [9]: Stage 1, sCr elevation $\geq$1.5 times the baseline; Stage 2, $\geq$2 times the baseline; Stage 3, $\geq$3 times the baseline or sCr $\geq$4.0 mg/dL or complete loss of kidney function requiring renal replacement therapy. Pre-existing CKD was defined based on eGFR <60 mL/min/1.73 m^2 for at least 3 months prior to the surgery. Net fluid balance equaled the sum of fluid input minus fluid output (in liters).

Statistical analysis

Statistical analysis was performed using JMP statistical software (version 9.0; SAS Institute, Cary, NC, USA). Continuous variables were reported as mean ± SD or median with interquartile range (IQR), as appropriate, and were compared using Student's t-test. Categorical variables were reported as counts with percentages and were compared using the chi-squared test. Univariate and then multivariate logistic regression analyses were performed to identify pre- or intraoperative factors associated with postoperative AKI. Variables significantly associated with postoperative AKI (P < 0.05 in univariate analysis) were included in the multivariate models; the model with the lowest Akaike information criterion (AIC) was subsequently selected as the final model. The difference in postoperative AKI occurrence between the cohorts 2002–03 and 2011–13 was determined using logistic regression. We adjusted the odds ratio (OR) for differences in baseline clinical characteristics between the two cohorts, including history of hypertension, coronary artery disease, myocardial infarction, left ventricular ejection fraction (LVEF), Charlson comorbidity score and preoperative eGFR. Postsurgery patient survival in those with and without AKI was presented using a Kaplan–Meier plot and was compared using the log-rank test. Cox proportional hazards analysis was used to examine the association between AKI and all-cause mortality. A two-tailed P-value <0.05 was considered statistically significant.

Results

Patient characteristics

A total of 701 consecutive octogenarians underwent heart valve replacement surgery from 1 January 2011 to 31 December 2013. Sixty-three patients were excluded for valve repair without valve replacement, 179 for transcatheter valve replacement instead of open-heart surgery and 7 for dialysis dependence (Figure 1). A resultant total of 452 octogenarians were studied as the contemporary cohort. As shown in Table 1, the mean age of the cohort was 84 ± 3 years, 60% were male, 77% had hypertension on treatment, 44% had documented coronary artery disease, 11% had prior episodes of myocardial infarction, Charlson comorbidity score was 2.1 ± 2.0, 58% had eGFR <60 mL/min/1.73 m^2 and baseline sCr was 1.1 ± 3 mg/dL, corresponding to a mean eGFR of 57 ± 16 mL/min/1.73 m^2.

To assess whether there was a change in the preoperative health status in the octogenarians between the last and current decades, we compared the above results with the data from the past cohort in the years 2002–03 (Table 1). More patients in the contemporary cohort were treated for hypertension [77% (n = 347) versus 61% (n = 127), P < 0.01]. Coronary artery disease, however, was less [44% (n = 143) versus 68% (n = 201), P < 0.01], prior myocardial infarction was less [11% (n = 49) versus 17% (n = 35), P = 0.04], congestive heart failure was less [21% (n = 93) versus 80% (n = 167), P < 0.001] and preoperative LVEF was better [58 ± 11% versus 55 ± 15%, P < 0.004]. Other differences included baseline sCr and eGFR, which were also better for the contemporary cohort [sCR, 1.1 ± 0.3 versus 1.2 ± 0.3 mg/dL, P <0.001; eGFR, 57 ± 16 versus 50 ± 13 mL/min/1.73 m^2, P < 0.001, respectively]. Overall, preoperative octogenarians in the contemporary cohort appeared to be healthier.

The type of valve surgeries performed was similar (Table 2). Mechanical valves were used more often in the current era [9%
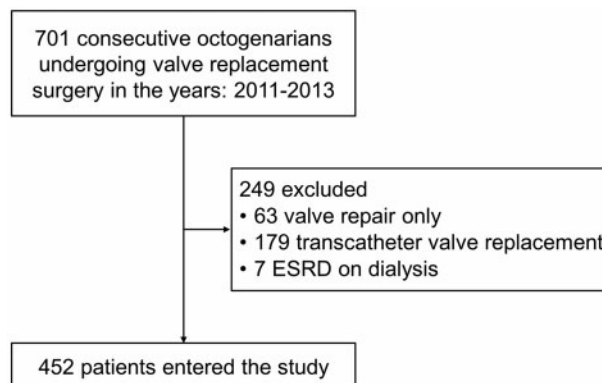

Fig. 1. Study patients in the years of 2011–13.

Table 1. Preoperative clinical characteristics of the two octogenarian cohorts in the years 2002–03 and 2011–13

Variable	2002–03 ($n = 209$)	2011–13 ($n = 452$)	P-value
Age (years)	85 ± 3	84 ± 3	0.07
Male	115 (55)	272 (60)	0.21
BMI (kg/m^2)	27.7 ± 5.3	28.2 ± 5.0	0.25
Diabetes mellitus	38 (18)	103 (23)	0.18
Hypertension	127 (61)	347 (77)	<0.001
Coronary artery disease	143 (68)	201 (44)	<0.001
Prior myocardial infarction	35 (17)	49 (11)	0.04
Congestive heart failure	167 (80)	93 (21)	<0.001
Chronic pulmonary disease	33 (16)	82 (18)	0.46
CKD, eGFR < 60 mL/min/1.73 m^2	164 (78)	260 (58)	<0.001
Charlson comorbidity index	2.6 ± 1.8	2.1 ± 2.0	<0.001
Baseline Cr (mg/dL)	1.2 ± 0.3	1.1 ± 0.3	<0.001
Baseline eGFR (mL/min/1.73 m^2)	50 ± 13	57 ± 16	<0.001
Preoperative EF	55 ± 15	58 ± 11	0.004

Continuous variables are reported as mean ± SD. and categorical variables are reported as n (%). BMI, body mass index; EF, ejection fraction.

Table 2. Surgical and intraoperative characteristics of the two octogenarian cohorts in the years 2002–03 and 2011–13

Variable	2002–03 ($n = 209$)	2011–13 ($n = 452$)	P-value
Valve surgery			
Aortic valve	191 (91)	390 (86)	0.06
Mitral valve	25 (12)	75 (17)	0.12
Tricuspid valve	8 (4)	40 (9)	0.02
Multiple valve surgery	14 (7)	47 (10)	0.13
Mechanical valve	3 (1)	41 (9)	<0.001
Concurrent CABG	122 (58)	162 (36)	<0.001
Intraoperative course			
Surgical duration (min)	349 ± 97	259 ± 103	<0.001
CPB time (min)	99 ± 41	103 ± 52	0.32
Aortic cross-clamp time (min)	69 ± 31	76 ± 38	0.02
Hemoglobin (g/dL)	8.1 ± 1.1	8.2 ± 1.1	0.44
RBC transfusion (mL)	890 ± 857	482 ± 723	<0.001
0.9% NaCl (mL)	1023 ± 844	517 ± 508	<0.001
Fluid balance (mL)	5295 ± 3382	2670 ± 2518	<0.001
IABP use	11 (5)	15 (3)	0.24

Continuous variables are reported as mean ± SD and categorical variables are reported as n (%).

($n = 41$) versus 1% ($n = 3$), P < 0.001]. Concomitant coronary artery bypass grafting (CABG) was performed less [36% ($n = 162$) versus 48% ($n = 122$), P < 0.001].

Operative course

Several significant differences during the operative period were identified (Table 2) between the two cohorts. Compared with the past cohort, surgical duration was shorter in the contemporary cohort [259 ± 103 versus 349 ± 97 min, P < 0.001], aortic cross-clamp time was slightly longer [76 ± 38 versus 69 ± 31 min, P = 0.02], intraoperative nadir hemoglobin was similar, but red blood cell (RBC) transfusion was less [482 ± 723 versus 890 ± 857 mL, P < 0.001] and intravenous 0.9% saline use was less [517 ± 508 versus 1023 ± 844 mL, P < 0.001], as was the net total fluid balance [2670 ± 2518 versus 5295 ± 3382 mL, P < 0.001]. These intraoperative factors could have impacted the occurrence of postoperative AKI.

Occurrence, severity and predictors of postoperative AKI

A total of 35.0% ($n = 158$) of the 452 octogenarians in the contemporary cohort developed postoperative AKI. In univariate analysis, compared with non-AKI patients, AKI patients were predominately males, had higher baseline sCr and lower eGFR as well as lower preoperative LVEF (Table 3). The AKI patients also had several intraoperative AKI risk factors, including longer surgical duration, longer cardiopulmonary bypass (CPB) and cross-clamp times, lower nadir intraoperative hemoglobin, higher volumes of RBC transfusion and higher percentage of intra-aortic balloon pump (IABP) use. The intraoperative fluid administrations, however, were similar. Most of the AKIs were of mild severity. Of the 158 AKI patients, 86.7% ($n = 137$) were in Stage 1, 5% ($n = 8$) in Stage 2 and 8.2% ($n = 13$) in Stage 3 (Table 4). Multivariate analysis for predictors associated with postoperative AKI in this contemporary cohort showed baseline sCr {OR 2.04 [95% confidence interval (CI) 1.10–3.84]} and surgical duration [OR 1.23 (95% CI 1.10–1.38)] to be independent risk factors for AKI.

Table 3. Comparison between AKI and non-AKI octogenarians in the contemporary (2011–13) cohort

Baseline characteristics	AKI (n = 158)	Non-AKI (n = 294)	P-value
Age (years)	84 ± 3	84 ± 3	0.89
Male	106 (67)	166 (56)	0.03
BMI (kg/m^2)	28.0 ± 5.2	28.3 ± 4.9	0.66
Diabetes mellitus	33 (21)	70 (24)	0.48
Hypertension	115 (73)	232 (79)	0.14
Coronary artery disease	77 (49)	124 (42)	0.18
Prior myocardial infarction	20 (13)	29 (10)	0.36
Congestive heart failure	32 (20)	61 (21)	0.90
Chronic pulmonary disease	30 (19)	52 (18)	0.73
CKD, eGFR < 60 mL/min/1.73 m^2	99 (63)	161 (55)	0.10
Charlson comorbidity index	2.3 ± 2.1	2.0 ± 2.0	0.24
Baseline Cr (mg/dL)	1.2 ± 0.4	1.1 ± 0.3	0.002
Baseline GFR (mL/min/1.73 m^2)	55 ± 16	59 ± 15	0.02
Preoperative EF	56 ± 13	59 ± 10	0.01
Surgical characteristics			
Valve surgery			
Aortic valve	132 (84)	258 (88)	0.21
Mitral valve	31 (20)	44 (15)	0.20
Tricuspid valve	19 (12)	21 (7)	0.08
Pulmonary valve	1 (0.6)	0 (0)	0.17
Multiple valve surgery	22 (14)	25 (9)	0.07
Mechanical valve	10 (6)	31 (11)	0.14
Concurrent CABG	63 (40)	99 (34)	0.19
Intraoperative course			
Surgical duration (min)	385 ± 130	333 ± 96	<0.001
CPB time (min)	116 ± 58	96 ± 46	<0.001
Aortic cross clamp time (min)	83 ± 40	73 ± 36	<0.001
Hemoglobin (g/dL)	8.0 ± 1.1	8.3 ± 1.1	0.03
RBC transfusion (mL)	662 ± 963	385 ± 530	0.001
0.9% NaCl use (mL)	535 ± 506	508 ± 509	0.59
Fluid balance (mL)	2704 ± 3145	2653 ± 2112	0.85
IABP use	11 (7)	4 (1)	0.002
Outcomes			
Hospital mortality	13 (8)	0 (0)	<0.001
Length of hospital stay (days), median (IQR)	9 (6–13)	6 (5–8)	<0.001
Discharge to a care facility	93 (64)	150 (51)	0.009

Continuous variables are reported as mean ± SD and categorical variables are reported as n (%). BMI, body mass index.

Compared with the octogenarians from the previous decade, the occurrence rate of postoperative AKI fell from 47% to 35%, (P = 0.003). The severity of AKI has also trended toward being less severe, with most AKI in the current decade in Stage 1, and accordingly, fewer patients required dialysis (6% versus 3% in the past cohort, P = 0.03) (Table 4).

Mortality, length of hospital stay (LOS) and discharge disposition

Hospital mortality occurred exclusively in AKI patients in the contemporary cohort (Table 3) [8% (n = 13) in 158 AKI versus 0% (n = 0) in non-AKI patients, P < 0.001]. The median LOS was longer for patients with AKI [9 (IQR 6–13) versus 6 (IQR 5–8) days for those without AKI, P < 0.001]. Likewise, the number of patients being discharged to a care facility was greater in those with AKI [64% versus 51% without AKI, P = 0.009].

Compared with the results from the past cohort, overall hospital mortality decreased from 6% to 3% (13 of the 452 in the contemporary cohort, P = 0.04) (Table 4). The mortality in the contemporary cohort in this study was similar to the hospital mortality reported in a recent study of octogenarians

undergoing aortic valve replacement [10]. Overall LOS decreased from 9 (IQR 7–14) to 7 (IQR 5–9) days (P < 0.001). The rate of discharge to a care facility increased, however, from 41% to 55% (P = 0.001).

Despite the reduction in hospital mortality, 1-year postoperative mortality rates in the non-AKI and AKI groups in the two cohorts were similar (Figure 2, showing a similar percentage survival among AKI and non-AKI cohorts). As more AKI patients in the contemporary cohort were in Stage 1, we compared mortality in Stage 1 AKI patients in the two cohorts. Disparate 1-year survival was noted; Stage 1 AKI in the contemporary cohort had a significantly reduced survival (Figure 3, Table 5).

Discussion

In this study, we show that the AKI occurrence rate among octogenarians following open valve replacement surgery in the current decade has fallen compared with that of a decade ago. The octogenarians in the current decade are healthier prior to surgery and have a reduced number of known AKI risk factors. One possibility for this observation could be the availability of transcatheter aortic valve replacement in recent years as an

Table 4. Occurrence and severity of AKI, hospital mortality, length of hospital stay and discharge disposition in the two periods: 2002–03 and 2011–13[a]

Outcomes	2002–03 ($n = 209$)	2011–13 ($n = 452$)	P-value
AKI	98 (47)	158 (35)	0.003
Dialysis	13 (6)	12 (3)	0.03
AKI stage[b]			0.11
Stage 1	75 (77)	137 (86)	
Stage 2	9 (9)	8 (5)	
Stage 3	14 (14)	13 (8)	
Discharge sCr	1.3 ± 0.5	1.1 ± 0.4	<0.001
Hospital mortality	13 (6)	13 (3)	0.04
AKI stages in hospital mortality			0.08
No AKI	1 (8)	0 (0)	
Stage 1	1 (8)	6 (46)	
Stage 2	2 (15)	0 (0)	
Stage 3	9 (69)	7 (54)	
LOS after surgery (days), median (IQR)	9 (7–14)	7 (5–9)	<0.001
LOS after surgery in AKI patients[b], median (IQR)	11 (8–16)	8 (6–11)	0.006
Discharge to a care facility[c]	81 (41)	243 (55)	0.001

Continuous variables are reported as mean ± SD and categorical variables are reported as *n* (%). [a]OR for postoperative AKI = 0.61 (95% CI 0.44–0.85), P = 0.004; adjusted OR for postoperative AKI = 0.60 (95% CI 0.39–0.93), P = 0.02. Adjusted for history of hypertension, coronary artery disease, myocardial infarction, congestive heart failure, eGFR, Charlson comorbidity score and preoperative LVEF.
[b]In AKI patients.
[c]In hospital survivors.
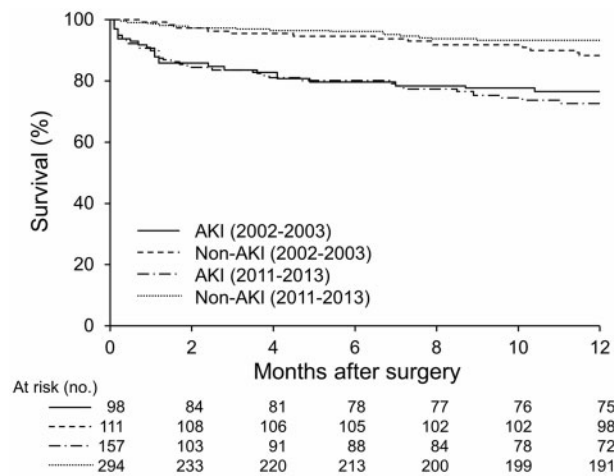
Fig. 2. One-year mortality in AKI and non-AKI octogenarians in the two study periods: 2002–03 and 2011–13.

option for high-risk octogenarians. Accordingly, the adverse outcomes have declined that could have potentially been associated with the reduction in the occurrence of postoperative AKI.

Previous studies examined the trend of post–cardiac surgery AKI between 1999 and 2008 in adults with all age ranges [11]. For elderly patients undergoing valve replacement surgery, outcome studies have mostly focused on mortality [10, 12–15]. There have been no data specifically addressing the occurrence and implications of postsurgery AKI in octogenarians, nor information on surgery-related AKI risk factors (i.e. surgical time, operative time and perioperative fluid administration). Our study targets AKI and AKI risk factors, which demonstrated higher baseline sCr and longer surgical duration as independent risk factors for post–cardiac surgery AKI in octogenarians. In

addition, we found that the overall AKI risk factors have, to a degree, minimized over the last decade for octogenarians undergoing valve replacement surgery, associated with a lower occurrence of postoperative AKI. Despite less AKI and less AKI-attributable mortality in the entire cohort, mortality among patients with Stage 1 AKI has paradoxically increased when compared with the data in the octogenarian counterparts in the previous decade (Figure 3). These results are at odds with previous studies reflecting data prior to 2010 [11], reporting an increased occurrence of postoperative AKI but a reduced mortality associated with AKI.

The differing observations shown in this study could reflect changes in practice in the current decade, in that known AKI risk predictors have been more recognized, possibly contributing to the minimization of these modifiable risk factors and subsequent reduction of AKI occurrence. For instance, patients from the current decade (deemed suitable for the surgery) had a better preoperative eGFR and shorter surgical duration. There have also been fewer combination surgeries of coronary artery bypass with valve replacement, and postoperative fluid use has been reduced as growing evidence suggests deleterious effects of postoperative fluid overload [16, 17]. Specifically for octogenarians, our prior study showed that large-volume postoperative fluid administration was an independent predictor for postoperative AKI [6]. All of these factors could have influenced the occurrence of postoperative AKI.

The finding of higher 1-year mortality in Stage 1 AKI octogenarians in the contemporary cohort compared with those in the past cohort was unexpected. On further evaluation of the results, several explanations may be offered. First, the baseline sCr was higher in the 2002–03 cohort than that in the 2011–13 cohort. The sCr elevation (in AKI) from a higher baseline corresponds to a smaller change in the percentage of sCr, reflecting a lesser magnitude of kidney function change [18]. For instance, a 0.3 mg/dL sCr increase from a baseline of 2.5 mg/dL can be very
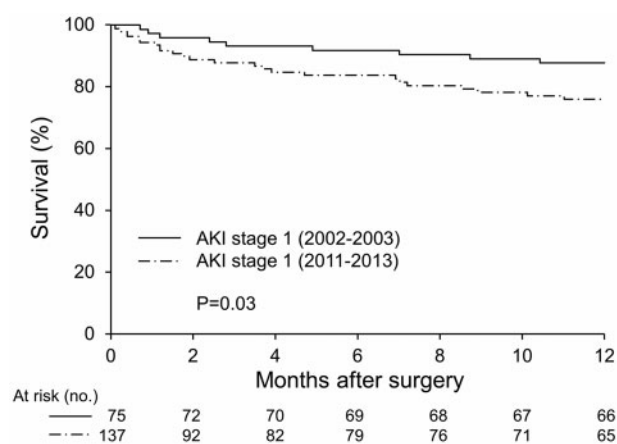
Fig. 3. One-year mortality in Stage 1 AKI in the two study periods: 2002–03 and 2011–13.

Table 5. Hazard ratio for Stage 1 AKI and 1-year mortality in the two study periods: 2002–03 and 2011–13

	HR (95% CI)	Adjusted HR (95% CI)
2002–03		
Stage 1	1.04 (0.43–2.42)	1.20 (0.49–2.84)
2011–13		
Stage 1	4.03 (2.19–7.68)	3.42 (1.83–6.58)

Adjusted for Charlson comorbidity index, hypertension, coronary artery disease, eGFR and preoperative LVEF.

ischemia and ischemia–reperfusion injury]. Renal tubular damage in these settings may exert a stronger mortality influence. Lastly, AKI in the current era might be related to yet to be identified factors that exert a stronger clinical impact.

This study has several notable clinical implications. Despite the emergence of less invasive options (for instance, transcatheter valve replacement procedures), judging by the number of patients in the two study periods, the number of octogenarians requiring or being offered open-heart valve surgery has continued to increase over the last decade, signifying an ongoing and increasing demand. Thus, information revealed by this study is relevant to the current practice and to decision making for contemporary octogenarians undergoing valve replacement surgery. The new trend of reduction in the occurrence of AKI but a stronger contribution to AKI-associated mortality likely represents a shift in practice toward more careful patient selection and minimization of the known AKI predictors. Less healthy and high-risk patients are more likely to undergo transcatheter valve replacement procedures [24]. The morbidity and mortality significance of postoperative AKI has clearly been demonstrated, which underscores the importance of further investigation to better understand the AKI disease process.

There are several limitations to the current study. First, this is a retrospective observational study. Data were based on the institutional electronic medical record, limiting the ability to address potential AKI risk factors that were not included in the records. In particular, the absence of reliable data on urine output necessitated an AKI diagnosis based solely on sCr, which is less ideal than the combination of sCr and urine output. However, we applied uniform AKIN criteria to both study periods, making the comparison more reliable. Second, the postoperative follow-up was limited to 1 year. Although relatively short, based on our previous observation in octogenarians [6], the greatest mortality impact of AKI is within the first operative year. Third, although we were able to determine and compare the level of comorbidities between the two octogenarian cohorts using the Charlson comorbidity index, specific data on frailty were lacking. Given the emerging data showing a risk of post–cardiac surgery mortality with increasing frailty [25, 26], it would have been informative if frailty data on the cohorts were available. Additionally, there might be other factors that have changed in the last 10 years that were not captured in the analysis that potentially contribute to the observed difference in this study. We have, however, taken all identifiable variables into account in the data analysis. As this is a single-center study, the care teams and care habits have not substantially changed in the study periods. Lastly, the vast majority of patients were Caucasian, making it difficult to generalize the information to other racial groups.

Conclusions

This study provides new information on the occurrence and clinical implications of AKI in octogenarians after heart valve replacement surgery. There has been a reduction in the occurrence of postoperative AKI in the octogenarians in the current era, likely related to a combination of better patient preoperative health status, improved surgical technique and reduced perioperative fluid administration. However, octogenarians with AKI continue to exhibit an increased morbidity and mortality burden compared with their non-AKI counterparts, attesting to the pressing need for a better understanding of AKI pathogenesis and for the development of early AKI detection and treatment strategies.

different from the same sCr increase from a baseline of 0.8 mg/dL with regard to the degree of kidney damage and the change in GFR. However, the two scenarios are classified as identical Stage 1 AKI. This premise was supported by eGFR in Stage 1 AKI between the two cohorts (49.8 in the 2002–03 cohort versus 55.1 mL/min/1.73 m^2 in the contemporary cohort, P = 0.014). Second, postoperative nonsteroidal anti-inflammatory drug (NSAID) use has likely decreased in the current era after a better realization of their deleterious intrarenal hemodynamic effects [19–21]. Regrettably, we were unable to precisely quantify the postoperative NSAID use for the 2001–03 cohort, but have a strong suspicion that NSAID use was relatively common during that period. We were able to quantify the postoperative NSAID (ketorolac) use in the contemporary cohort (2011–13). Only 1 of the 452 octogenarians received parenteral ketorolac during the 7-day postoperative period, much lower than the historical data [22]. Transient postoperative NSAID use can cause adverse renal hemodynamic effects, especially for patients with CKD, potentially leading to a diagnosis of Stage 1 AKI, which is, in essence, a functional change rather than tubular structural damage. The lack of mortality of Stage 1 AKI in octogenarians in the last decade could have been consistent, at least in part, with short-term NSAID use, which may have exerted less mortality influence [23]. Third, when most of the known modifiable AKI predictors were minimized, those who developed AKI might have underlying less modifiable AKI-contributing factors [i.e. operation-related factors, including CPB duration, nadir hemoglobin (hemodilution and the amount of blood transfusion), undocumented intraoperative hemodynamic instability (especially in patients with chronic hypertension, which is more prevalent in the contemporary cohort) and events that might have engendered renal medullary

Authors' contributions

C.T., W.C., M.M., J.L. and Q.Q. performed data acquisition for the new cohort, statistical analysis and manuscript creation. Q.Q. conceived and supervised the project. All authors have read and approved the manuscript.

Conflict of interest statement

None declared.

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