A comparison of different diagnostic criteria of acute kidney injury in cardiac surgery patients

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Summary

Objective: To compare of three diagnostic criteria of acute kidney injury (AKI), included KDIGO, RIFLE and AKIN, for patients with cardiac surgery. *Subject and method:* A descriptive study on 247 patients underwent cardiac surgery with cardiopulmonary bypass in the 108 Military Central Hospital from January 2015 to September 2017. Serum creatinine (sCr) was measured at the following times: Arrival in ICU (T_0), 12 hours (T_1), 24 hours (T_2), and 48 hours (T_3) after to evaluate the incidence and severity of AKI according to three criteria (KDIGO, RIFLE and AKIN). *Result*: The incidence of AKI was 48.5% based on KDIGO, higher than that of RIFLE (39.6%) and AKIN (46.9%). The severity of AKI according to KDIGO I, II, III was 67.3%, 24.4% and 8.1% respectively; RIFLE R, I, F was 67.3%, 24.5%, and 8.1%; and AKIN I, II, III was 76.7%, 16.3% and 6.9% respectively. AKI patients had higher mortality (7.5% vs. 1.57%) and longer ICU and post-operative stays than non-AKI ones. *Conclusion*: KDIGO had better sensitivity for detect AKI than RIFLE and AKIN. AKI led to higher mortality, longer ICU and hospital stays after surgery.

Keywords: Acute kidney injury, cardiac surgery, diagnostic criteria.

1. Background

Acute kidney injury (AKI) is a common complication in patients with cardiac surgery; the incidence has ranged from 3.5 to 36.1%, depending on diagnostic criteria applied [6]. Post-operative AKI would lead to an increase of mortality from 0.4 - 4.4% to 1.3 - 22.3%. Especially in patients requiring renal replacement therapy, the mortality rate can be as high as 25% to 88.9%, 8 times higher than that of non AKI patients [2].

However, a problem in diagnosing and treating AKI is that, there have been over 200 definitions of AKI, making it difficult in applying in clinical practices and research. Therefore, for the last few years, some new definitions and diagnostic criteria of AKI were proposed, including RIFLE, AKIN and KDIGO. The aim of this study was to compare of these criteria, and also define some clinical outcomes of AKI after cardiac surgery.

2. Subject and method

2.1. Study cohort

A prospective and descriptive study, carried out on 247 adult patients (over 18 of age) undergoing cardiac surgery using cardiopulmonary bypass in 108 Military Central Hospital, from January 2015 to December 2017. Exclusion criteria included: The patients had

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chronic kidney disease requiring renal replacement therapy before operation; off-pump coronary artery bypass and not having enough data of serum creatinine pre- and post-operatively.

2.2. Data collection

Serum creatinine was examined at three time points after surgery: Arrival in ICU (T_0), 12 hours (T_1), 24 hours (T_2), and 48 hours (T_3) after to evaluate the incidence and severity of AKI according to three criteria (KDIGO, RIFLE and AKIN). We did not use the GFR or urine output criteria. For RIFLE and KDIGO criteria, we used the lowest sCr from the admission until operation as the baseline creatinin. For AKIN criteria, post-operative sCr was compared with the latest pre-operative level. Dates of admission, discharge from the ICU and the hospital, and in-hospital mortality was recorded.

Data were analyzed by using SPSS 17.0.1. A p-value of less than 0.05 was considered to be significant.

3. Result

During the study period, 247 patients were enrolled. The mean age of the patients was 53.3 ± 12.7 years, with male/female ratio of 1.5/1. Cardiac valve surgery accounted for 72.8%, meanwhile coronary artery bypass was 9.7%; the others were septal defects, atrial myxoma...

Table 1. AKI diagnosed with KDIGO, RIFLE and AKI

Definition	KDIGO (1) n (%)	RIFLE (2) n (%)	AKIN (3) n (%)
AKI (n, %)	120 (48.5%)	98 (39.6%)	116 (46.9%)
p	$p_{1-2}<0.05$	$p_{2-3}>0.05$	$p_{1-3}>0.05$

AKI was diagnosed in 48.5% patients by using the KDIGO classification, higher than that of AKIN (46.9%, p=0.07) and RIFLE (39.67%, p<0.05). Using RIFLE classification, 67.3% patients with Risk, 24.4% with Injury, and 8.1% with Failure. According to AKIN criteria, 76.7% with stage 1, 16.3% with stage 2, and 6.9% with stage 3. When KDIGO criteria were used, 73.3% with stage 1, 18.3% with stage 2, and 8.3% with stage 3.

Table 2. Agreement between KDIGO and RIFLE classifications

Definition		RIFLE				
		No-AKI	R	I	F	Total
KDIGO	No-AKI	127 (51.4)	0	0	0	127 (51.4)
	I	22 (8.9)	66 (26.7)	0	0	88 (35.6)
	II	0	0	22 (8.9)	0	22 (8.9)
	III	0	0	2 (0.8)	8 (3.2)	10 (4.1)
	Total	149 (60.3)	66 (26.7)	24 (9.7)	8 (3.2)	247 (100)

The KDIGO criteria identified 22 more patients with AKI than the RIFLE criteria did, and all 22 these patients were identified by an increase in creatinine alone. 2 patients were defined by KDIGO as stage 3 but not as Failure by RIFLE.

Table 3. Agreement between KDIGO and AKIN classifications

Definition	AKIN

		No-AKI	I	II	III	Total
KDIGO	No-AKI	127 (51.4)	0	0	0	127 (51.4)
	I	4 (1.6)	84 (34.0)	0	0	88 (35.6)
	II	0	4 (1.6)	18 (7.3)	0	22 (8.9)
	III	0	1 (0.4)	1 (0.4)	8 (3.2)	10 (4.0)
	Total	131 (53.0)	89 (36.0)	19 (7.7)	8 (3.2)	247 (100)

Compared with the AKIN criteria, KDIGO diagnosed only 4 more patients as having AKI; all of them were categorized as stage 1.

After operation, using KDIGO definition, 11.6% of AKI were detected when the patients arrived in ICU; 24.1% after 12 hours; 42.5% on the 2nd day (24 hours) and 21.6% on the 3rd day (48 hours).

Table 4. Association between acute kidney injury and length of stays

AKI	No-AKI (n = 127) $\bar{x}$ ± SD	AKI - I (n = 88) $\bar{x}$ ± SD	AKI - II (n = 22) $\bar{x}$ ± SD	AKI - III (n = 10) $\bar{x}$ ± SD	p
ICU stay (day)	2.4 ± 1,1	3.5 ± 3.4	5.1 ± 4.9	6.0 ± 3.7	<0.001
Post-operative hospital stay (day)	14.0 ± 7.5	16.8 ± 8.6	20.3 ± 10.3	17.9 ± 6.5	<0.01

Length of ICU stay and post-operative hospital stay increased with the severity of AKI, and were longer in patients with AKI than in those without AKI (p<0.01).

Table 5. Association between acute kidney injury and mortality

AKI	No-AKI[1] (n = 127) n (%)	AKI[2] (n = 120) n (%)	Total (n = 247) n (%)	p^{1-2*}
Mortality	2 (1.6%)	9 (7.5%)	11 (4.4%)	<0.05

The overall in-hospital mortality rate after surgery was 4.4%, in which the mortality was significantly higher for AKI patients than for non-AKI patients (7.5% versus 1.6%, p<0.05).

4. Discussion

In this study, we investigated the AKI incidence in patients after undergoing cardiac surgery, applying three different criteria; in which the main one was KDIGO which was used to compare with RIFLE and AKIN.

The RIFLE definition was introduced in 2004 [1] by Acute Dialysis Quality Initiative (ADQI) Group. In RIFLE, AKI is defined by increased serum creatinine increases ≥ 1.5-fold or decreased glomerular filtration rate ≥ 25% the baseline levels. RIFLE defines three grades of increasing severity of acute kidney injury - risk (class R), injury (class I) and failure (class F) - and two outcome classes (loss and end-stage kidney disease). In 2007, the Acute Kidney Injury Network (AKIN) group proposed a modified version of the RIFLE classification, which aimed to improve the sensitivity of AKI criteria [9]. There were several changes: An absolute increase in sCr of at least 26.5μmol/L was added to stage 1; patients starting RRT were classified as stage 3, irrespectively of sCr; and the change in glomerular filtration rate (GFR) and the two outcome classes were removed.

The latest classification was proposed by the Kidney Disease: Improving Global Outcomes

(KDIGO), was based on the previous two classifications, and had the aim of unifying the definition of AKI [5]. According to this definition, AKI was diagnosed as an increase in sCr by at least 26.5µmol/L within 48 hours or an increase in sCr to 1.5 times baseline, which is known or presumed to have occurred within 7 days before, or a urine volume of less than 0.5mL/kg per hour for 6 hours. For staging, KDIGO keeps the same stages as AKIN, but adding sCr of more than 4.0mg/dL (354µmol/L) to diagnose stage 3.

In our study, according to KDIGO definition, the incidence of AKI after cardiac surgery was 48.5%, in which stage I accounted for 73.3%, stage II for 18.3% and stage III for 8.3% (Table 1). It was similar to the results of some other study on cardiac surgery patients. In a recent study of Howitt et al (2018) [4], the AKI rate was 36.1%. Similarly, in a study of Machado et al (2014) [8] on 2,804 patients undergoing cardiac surgery under cardiopulmonary bypass, the AKI was seen in 42%; the majority was stage I (35%), and then stage II (4%) and stage III (3%); 2% of total AKI needed renal replacement therapy.

In comparison with RIFLE, the AKI rate was significantly higher when using KDIGO (48.5% versus 39.6%, $p<0.05$). KDIGO helped to detected 22 patients who were not defined by RIFLE; meanwhile, no patient was detected more by RIFLE. All of 22 patients were identified by an increase in creatinin (≥ 26.5µmol/L) alone; but did not met the requirement of 1.5-fold increase by RIFLE. There were 2 patients, belonging to stage *Injury* of RIFLE, but was at stage 3 of KDIGO due to indication of renal replacement therapy (Table 2).

In comparison with AKIN, KDIGO also detected more AKI than AKIN (48.5% versus 46.9%), but the difference was not significant ($p>0.05$). Only 4 patients were defined more by KDIGO, and all of them were at the stage I (Table 3). Because KDIGO used the lowest level of creatinine as baseline, so in stage 3 of KDIGO, 2 patients had 3-fold increase from the baseline, but not 3-folds higher than the latest creatinine prior to operation, so they were classified as stage 2 of AKIN.

In patients with cardiac surgery, there have been some studies comparing AKI criteria. In a meta-analysis of Xiong et al. on total of 171,559 patients from 19 studies, the AKI incidence based on AKI was higher than that on RIFLE. The cause was the adding of an increase of 25.6µmo/L of creatinine to AKIN; classifying RRT patients (due to overload) as stage 3 and getting rid of using GFR in diagnosing AKI. However, no difference was in mortality predicting between RIFLE and AKIN [10].

Since KDIGO definition was introduced to unify two previous criteria, many studied were carried out to compare them. In a study of Luo et al (2014) on 3107 patients; the results showed that KDIGO was more sensitive to detect AKI than RIFLE and AKIN (51% versus 46.9% and 38.4% respectively). The explanation was that, KDIGO consists of definitions of both RIFLE and AKIN. The KDIGO application was also easier than RIFLE in patients with un-known baseline creatinine or GFR. At present, KDIGO definition has been recommended by Acute Dialysis Quality Initiative (ADQI) Group in cardiac surgery patients other than RIFLE.

Regarding to the onset of AKI; we found that most AKI was seen just when arrival in ICU and on the first day after surgery. So, it can be implied that, there would be some risk factors to AKI, early in the pre- and intra- operative periods. In fact, many studied have identified these risk factors of AKI in cardiac surgery. They include the old age, previous kidney dysfunction, diabetes, severe heart failure…. Especially, cardiopulmonary bypass is seen as the highest risk to AKI. The mechanism of this process was complicated, relating to many factors which badly affect to kidney function, like decreased blood perfusion, ischemia/reperfusion injury, inflammation and oxidase stress…

Regarding to the outcomes of AKI after cardiac surgery, according to increasing severity of AKI, the length of ICU stay and post-operative hospital stay were also increased and longer than those of non-AKI patients. The mortality rate was also higher in AKI group (7.5% versus 1.6%, $p<0.05$) (Table 5). This result was similar to some other studies in the world, in which, AKI was proved to be the independent risk factor of cardiac surgery - AKI. The in-hospital mortality or within 30 days was from 3.8 - 54.4% in AKI patients; this will go up in accordance with the AKI severity. The highest mortality rate was in patients needing RRT, which could reach to 50 - 60% of death [3].

5. Conclusion

KDIGO was more sensitive in detecting AKI than RIFLE and AKIN. Patients having AKI after cardiac surgery had longer ICU and hospital stay, and also higher mortality rate.

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