Identification of the oliguric patient using a novel electronic urine flow-rate device

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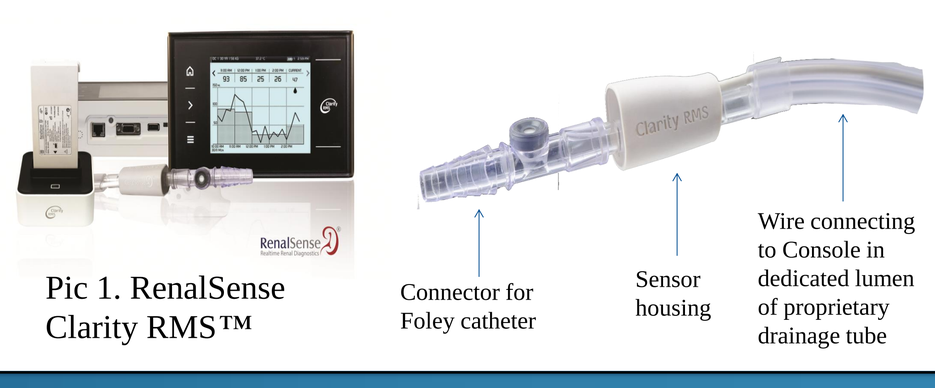
Introduction: Oliguria has most recently been defined as urine output (UO) <0.5ml/kg/hr for six consecutive hours (1). Criteria for identifying acute kidney injury (AKI) according to RIFLE, AKIN and KDIGO, define injury levels according to measurements of serum creatinine (SCr) and UO (2). However, only a small percentage of AKI studies incorporate UO measurements (3). A prospective observational study was performed to identify oliguric patients using a novel electronic urine monitoring device.

Study Population: 63 hospitalized patients in the General ICU at Hadassah Hospital, Jerusalem, Israel with an indwelling urinary catheter. The Hadassah IRB approved the study and informed consent was waived. Patients included were >18 yrs, expected to stay in the ICU for at least 24 hours, with no evidence of AKI according to their SCr prior to their inclusion.



Pic 1. RenalSense Clarity RMS™

Study design: The RenalSense Clarity RMS™ electronically monitored urine output (Pic 1). For this study, the Clarity RMS Sensor Kit™ included a urinometer for the nursing staff to record UO as per standard practice. Sensor measurements were validated on a scientific scale. The medical staff was blinded to both Clarity RMS and scale measurements. Patient population was divided into AKI and non-AKI based on three methods using the KDIGO criteria: 1. SCr criteria only (N=62), 2. UO criteria only (N=63), 3. SCr+UO criteria (N=63) (1). Daily SCr was collected from patient records up to seven days following Clarity RMS removal. Relevant fluids and medication were recorded. Readmissions and all cause in-hospital mortality were included for up to one year of follow-up (SAS statistical software v9.4, SAS Institute, USA).

Table 1. Identification of AKI in the study population using 3 methods:

Study Groups		n (%)	ICU days (LOS)		In-hospital all-cause mortality
			Median	Average	n (%)
SCr	AKI	15(24.2%)	10.9	20.0	3 (20%)
	Non-AKI	47(75.8%)	4.0	6.0	5 (10.6%)
UO	AKI (stage 1)	11(17.5%)	7.0	8.6	2 (18.2%)
	AKI (stage 2)	23(36.5%)	7.5	13.6	5 (21.7%)
	Non-AKI	29(46.0%)	3.9	5.6	3 (10.3%)
SCr + UO	AKI (both)	13 (20.6%)	17.4	23.0	3 (23.1%)
	AKI (one)	23 (36.5%)	5.3	6.2	4 (17.3%)
	Non-AKI	27 (42.9%)	3.7	5.7	3 (11.1%)

Results : Follow-up on the study group ranged from 30 days to one year after release from the initial ICU stay. Patient demographics, including age, weight, gender, cause of admission, and risk factors (such as age >70, mechanical ventilation, inotrope administration, morbid obesity, diabetes, hypertension, congestive heart failure, and chronic lung or liver disease), did not differ significantly between the AKI and non-AKI groups in all three methods of dividing the study population.

LOS in SCr-only, UO-only, and SCr+UO groups was significantly longer for AKI patients than non-AKI patients ($p \leq 0.0023$, ≤ 0.0074, ≤ 0.0018 respectively) (Fig 1a, 1b, and 1c).

There were 13 patients in the AKI SCr+UO group (12 with AKI UO Stage 2, one with Stage 1). AKI was identified as much as 120 hours earlier by UO than by SCr (Fig 2).

In all three division methods AKI patients received significantly more fluid in the first 24 hours of UO monitoring than their non-AKI counterparts. Urine output monitored during this study provided a graphic display of response to repeated diuretic and fluids administration (Fig 3).

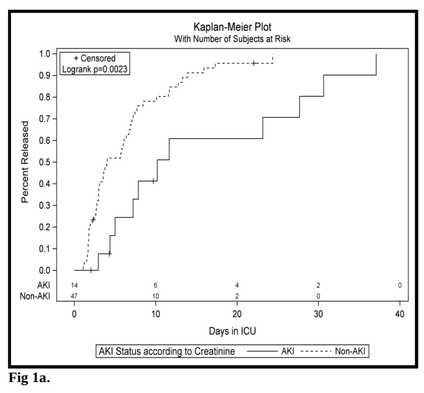


Fig 1a.

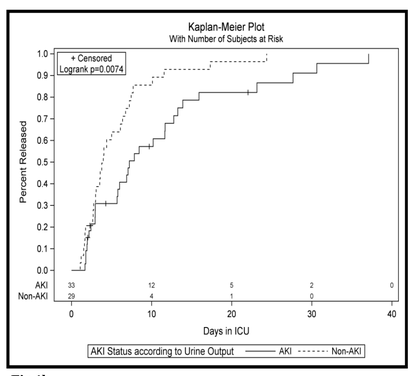


Fig 1b.

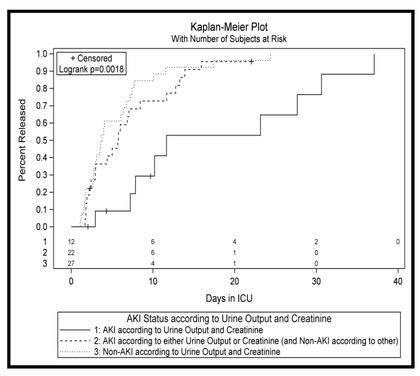


Fig 1c.

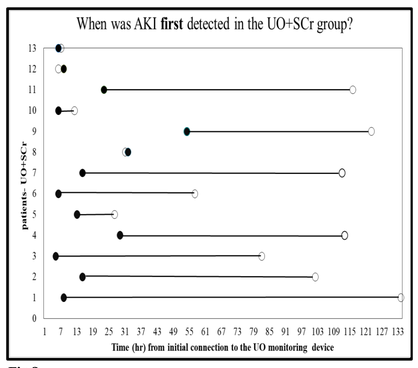


Fig 2.

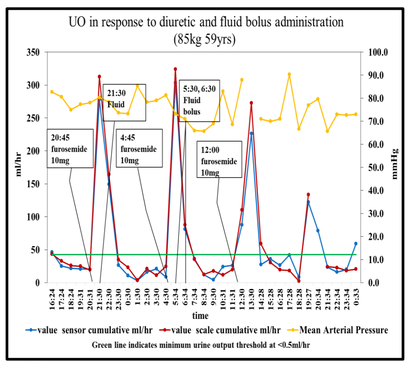


Fig 3.

Fig 1a. Time to release from ICU for AKI vs. non-AKI in SCr-only group.
Fig 1b. Time to release from ICU for AKI vs. non-AKI in UO-only group.
Fig 1c. Time to release from ICU for AKI vs. Non-AKI in SCR+UO group.
Fig 2. AKI patients in SCR+UO group. Filled circle = time to initial AKI UO diagnosis. Empty circle = time to initial AKI SCr diagnosis.
Fig 3. Hourly UO response to diuretic and fluid bolus.

Conclusion: Studies have shown worse outcomes in patients that fulfill AKIN criteria for both SCr and UO versus SCr alone (4). Relying on increased SCr alone to indicate AKI may be insufficient, as ICU patients tend to be fluid overloaded, thus diluting SCr measurements; UO measurements may be the only reliable indicator of AKI (2).

Our data shows UO-only AKI is correlated with increased length of stay in the ICU. Monitoring urine output in real-time will provide valuable information to identify AKI earlier, intervene earlier, and set protocol goals such as decisions for timely fluid and diuretic administration as well as evaluating response.

References: 1. Mehta R, Kellum JA, Shah S, et al. Acute kidney injury network: report of an initiative to improve outcomes in acute kidney injury. *Crit care*. 2007; 11:R31. 2. Luo X, Jiang L, Du B, et al. A comparison of different diagnostic criteria of acute kidney injury in critically ill patients. Beijing Acute Kidney Injury Trial (BAKIT) workgroup. Crit Care. 2014 Jul 8;18(4):R144. 3. Cruz DN, Ricci Z, Ronco C. Clinical review: RIFLE and AKIN – time for reappraisal. *Crit Care*. 2009; 13:211. 4. Kellum J , Sileanu FE, Murugan R, et al. Classifying AKI by Urine Output versus Serum Creatinine . J Am Soc Nephrol 26: 2231–2238, 2015.