Comparison of different AKI baseline algorithms using data from Doncaster & Bassetlaw Hospitals NHS Foundation trust.

R. Stott[1], I. Stott[2], M. Slokan[1]

1 Department of Pathology, DBH. 2 Department of Renal Medicine , DBH. Author email - richard.stott@dbh.nhs.uk

Initial assessment

We initially calculated the AKI level as a hidden test on our laboratory system to audit the performance prior to adding the logic to provide free text alerts. Our algorithm was based on the KDOKI criteria and used the lowest figure in the previous 72 hours as the baseline against which to assess any subsequent increase. A significant proportion of creatinine requests were on patients without a creatinine result in the previous 72 hours. Several baseline methods are suggested in the literature but we were unable to identify any studies which compared the performance of the calculation processes. We therefore designed our algorithm using the "lowest value" pattern and selected an arbitrary look-back period of 90 days. The system was completed on 10th April 2013 via the addition of logic to add free test comments to hospital results which triggered AKI1, AKI2 or AKI3. AKI3 alerts were telephoned from that date. Comments and telephoned alerts for AKI3 in community patients were commenced on 4/11/13.

Subsequently the ACB criteria for AKI calculation were agreed. While preparing to present our experience of AKI score calculation at a local meeting, we identified patients in whom AKI events were detected by our "lowest value" baseline method but not by a system based on a median value baseline. These patients did not have baseline results within the 3 days prior to their AKI event and therefore failed the strict KDIGO criteria but had a significant AKI event in the previous year which caused a markedly elevated median value.

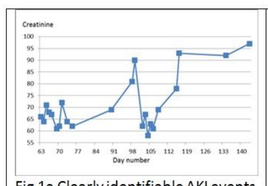


Fig 1a Clearly identifiable AKI events for a patient.

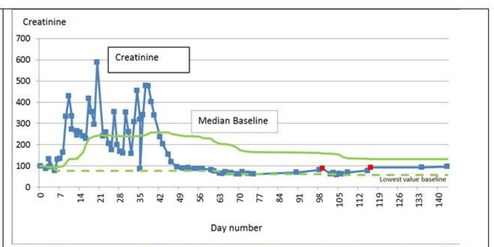


Fig 1B The same patient including previous creatinine results and the baseline values to show why the algorithms differ in their detection. (Red data points are the acutely increased values in 1A).

There were also patients where a potentially false alert would have been produced by our "lowest value" algorithm as a consequence of a single low creatinine result which was not consistent with the patient's baseline creatinine as assessed graphically.

We have more than 24 months of creatinine results obtained with the same enzymatic method and have therefore evaluated the performance of baselines based on the median, lowest value, age and gender and also a new method intended to avoid the potential problems with both the lowest value and median baselines.

The new method uses the same principle as the 10X Westgard rule for identifying internal QC values which may have made a stepwise change from the mean. A stable baseline should have half of the data points either side of the running median and they should be randomly distributed therefore the presence of successive data values on the same side of the median is a potential indication of a shift and becomes more likely to be a shift as more points appear on the same side of the median. The baseline is calculated starting from the oldest data point to be included and each new baseline value increments a count of the consecutive data points above and below the current median. When the count exceeds a pre-set number, the running median is re-calculated from the first point that side of the median. Therefore the baseline takes a stepwise move in the direction of any significant trend but is minimally disturbed by individual random values.

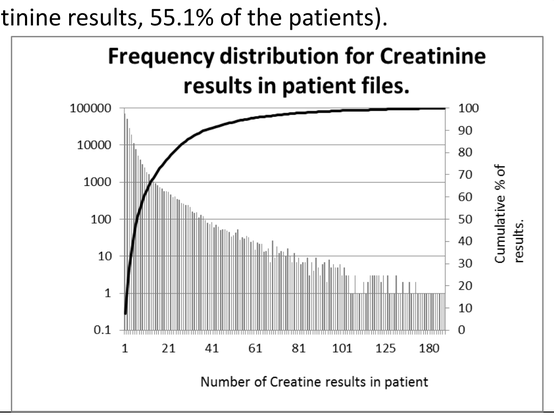
Method

All creatinine values for 24 months were extracted from the laboratory information system using a SQL query and organised into comma delimited patient specific files with results in consecutive order. These files were identified using the lab system internal ID number which is not traceable as it is only available to limited numbers of laboratory staff with access via SQL.
Programs were written in Microsoft Q Basic to create AKI alerts using each baseline process. Each program created a copy of the patient file identifying whether each data point had triggered an AKI alert and the grade. A method summary file was also created containing a list of scores for each patient file.

Results

Characteristics of the data available for AKI analysis were as follows -

- Total data points 924602 creating files for 220123 patients.
- 433474 data points were from males aged > 18 and 490784 from females aged > 18.
- Less than 2.5 % of data points were for patients aged < 18 at the time the samples were taken. Mean age of subjects was between 63 and 64 years for both genders (Range 0 to 114 years).
- 44.5% of the requests originated from primary care and 2.85% were requested by the renal team as identified via either the consultant or an associated location.
- For all except the age & gender determined baseline method, there is a requirement for at least 3 data points to generate an alert and therefore 121391 patient files (containing a total of 172918 data points) were too small to be useful and were not opened by the other evaluation programs (18.7% of the potentially available creatinine results, 55.1% of the patients).



Age & gender method.

Cutoff values from Second International Consensus Conference of the Acute Dialysis Quality Group (Bellomo et al Crit care 2004; 8: R204 – R212 – web http://ccforun.com/content/8/4/r204; As reprinted in Kidney International Supplements 2012;2, 19 – 36).

Minimum data points for evaluation	Number of patients reporting one or more AKI events (% all patients)	AKI 1	AKI 2	AKI 3
1	15647 (7.1%)	39229	20286	15914
3 (for comparability with other baseline methods)	14381 (6.5%)	38168	20114	15881

This method is the only one which would be available for over 50% of our patient population and was applied without access to ethnicity data. It alerts all values above a limit calculated from the lower limit for e-GFR and therefore falsely alerts for patients with elevated but stable results due to CKD.

We anticipated that this method would also miss AKI events because the "lowest point" baseline method had previously identified patients who routinely ran with values below or within the creatinine reference range and who experienced well defined AKI events when their results moved into or within the reference range.

Minimum value method.

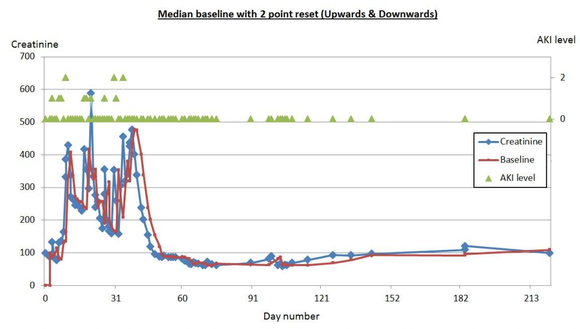
Days look-back	Number of patients reporting one or more AKI events (% all patients)	AKI 1	AKI 2	AKI 3
3 (KDIGO definition)	1817 (0.83 %)	2806	1023	435
30	4419 (2.01 %)	9836	4057	3928
60	5298 (2.41 %)	12604	4949	5342
90 (our original criterion)	5993 (2.72 %)	14723	5532	6004
120	6572 (2.99 %)	16585	6046	6477
240	8343 (3.79 %)	22249	7620	7643
360	9797 (4.45 %)	26821	8977	8371

Median & "Median with baseline reset" methods.

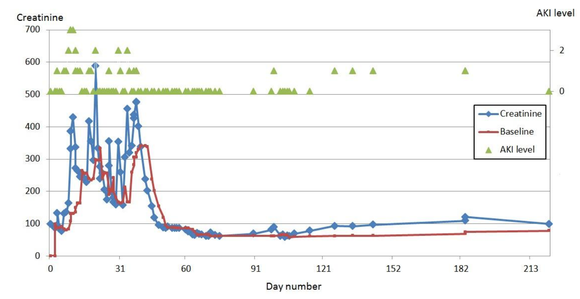
All for 365 days look back.

Number of successive results the same side of median to trigger baseline reset	Reset in both directions				Baseline reset downwards only			
	patients reporting one or more AKI events	AKI 1	AKI 2	AKI 3	patients reporting one or more AKI events	AKI 1	AKI 2	AKI 3
2	5545	7147	2055	1062	6455	11933	3919	1921
3	5536	7936	2334	1007	6101	11541	3654	1706
4	5595	8402	2483	1089	5926	11104	3474	1642
5	5605	8751	2590	1206	5808	10806	3410	1633
6	5602	8993	2727	1265	5736	10559	3354	1599
7	5586	6156	2832	1319	5628	10260	3273	1582
8	5565	9215	2863	1366	5468	9165	2885	1458
9	5553	9315	2916	1405	5591	10163	3249	1573
10	5535	9381	2950	1435	5563	10065	3228	1569
No reset (ACB Definition)	5525	9345	2960	1433				

The effect of the reset process is to allow the baseline to follow changes in creatinine values more closely than the median and therefore detects low grade AKI events following a more significant event. Allowing the "reset" in both directions causes the algorithm to alert for fewer high points within a cluster and alert them at a lower grade because the baseline rises more rapidly than would be the case with a simple median.



Limiting the reset process to results which are below the baseline allows the algorithm to retain alerts for significant increases within an event as well as improving the ability to alert for low grade acute increases after a series of elevated results. When a reset was triggered by 2 consecutive data points below the median, this method detected all of the AKI 1 events known to be present in the patient shown in figure 1.



Conclusions

At present we do not know the total number of acute creatinine increases in our patient data and therefore cannot formally assess sensitivity and specificity values for any of the baseline calculation algorithms. However, the increased number of AKI alerts produced and a limited graphical assessment of the algorithm performance suggest that this method may be valuable in detecting clinically significant AKI events in situations where a conventional median baseline fails to trigger an alert.
The current optimum number of data point to trigger the baseline reset may not be appropriate for other populations if requesting patterns vary and will need to be re-checked in future if AKI alerting causes a change in our local requesting frequency.

Acute Kidney Injury (AKI) Programme Board