

NHS BLOOD AND TRANSPLANT

LIVER ADVISORY GROUP

SUMMARY OF CUSUM MONITORING OF OUTCOMES FOLLOWING LIVER TRANSPLANTATION

INTRODUCTION

1. NHSBT monitors short-term patient outcomes following organ transplantation through centre-specific cumulative sum (CUSUM) analyses. These have been undertaken monthly for liver transplantation since 1 January 2002. These 'within-centre' analyses enable prompt detection of any changes in patient mortality rates, providing external assurance and enabling centres to compare current outcomes with their own past performance to assist in internal auditing.
2. CUSUM monitoring informs about a centre's performance with respect to that centre's own past performance. However, it is essential to complement CUSUM methods with 'between-centre' monitoring as, if a centre's performance remains unchanged over time but falls behind rates being achieved by others, this will not be identified through CUSUM monitoring.

CUSUM METHODOLOGY

3. CUSUM monitoring compares current outcome rates with an expected patient mortality rate. In particular, the tabular CUSUM chart summarises the extent to which observed outcomes are consistent with the expected mortality rate. The chart is designed to signal when the tabular CUSUM crosses a pre-defined threshold known as the chart *limit*.
4. The expected mortality is determined from a baseline period when performance is believed to be satisfactory. Current expected mortality rates were determined from the baseline period 1 January 2008 to 31 December 2011 and obtained as unadjusted centre-specific average patient mortality rates. They were presented to the LAG in November 2013 ([LAG\(13\)51](#)).
5. The tabular chart limit was determined using a simulation procedure, striking a balance between reducing the number of false signals and detecting real changes in mortality.
6. In 2008, the monitoring process was improved by introducing the 'head start' tabular CUSUM to liver transplantation. Normally, when a signal occurs, the CUSUM chart is 'reset' to zero, corresponding to a situation where any factors leading to poorer outcomes have been corrected. However, in transplantation, there is rarely a single cause for any deterioration in outcomes, and any changes may take time to have an impact. Accordingly, after a signal, it is desirable to monitor at a more stringent level. To do this, the CUSUM is restarted at some value between zero and the chart limit. This change addresses the need for a responsive enough system so that the chart re-signals more quickly after an initial signal if the outcomes remain inconsistent with those expected.

7. Each month, CUSUM reports on 90-day mortality following first-time liver transplantation are produced and sent to each centre. This paper summarises the results of these reports for the six month period since the last Liver Advisory Group meeting and, separately, it summarises signals since 2007. It also presents a number of areas where liver CUSUM reporting will be further developed.

RESULTS

8. **Table 1** shows that, over the six month period since the last Liver Advisory Group meeting, there have been no signals in liver transplantation CUSUM reporting.

Month CUSUM report issued	No. reports issued	No. signals	No. signals requiring investigation	No. investigations outstanding
April	7	0	0	0
May	7	0	0	0
June	7	0	0	0
July	7	0	0	0
August	7	0	0	0
September	7	0	0	0
Total	42	0	0	0

9. **Table 2** shows a summary of the CUSUM signals in liver transplantation since 2007.

Table 2 Summary of CUSUM signals in liver transplantation since 2007

Signal ID	Signal date	Centre	Transplant type	Donor type	Recipient age group	Investigation required	Investigation complete	Signal signed off
116	19/12/2013	Leeds	Elective / Standard	Deceased	Adult	Yes	Yes	Yes
75	31/01/2011	New castle	Elective / Standard	Deceased	Adult	Yes	Yes	Yes
57	15/07/2007	Birmingham	Elective / Standard		Adult	No	Yes	Yes
56	15/12/2007	Cambridge	Elective / Standard		Adult	Yes	Yes	Yes

CONCLUSION

10. Over the six month period since the last Liver Advisory Group meeting there have been no signals in liver transplantation CUSUM reporting.
11. Future developments
- Update of the baseline period so that more recent centre-specific mortality rates are used.
 - Introduction of risk adjustment of patient mortality rates.

- c. Review of the chart limit and, if thought desirable, update of the trigger to improve the sensitivity of the monitoring system.
- d. Currently, CUSUM charts monitor transplant outcome as a binary variable (alive/death) at 90 days post-transplant. This means that a complete 90-day follow up is needed and that a death at 89 days is treated differently from a death at 91 days. Work is planned to use the actual survival times of the patients as a continuous value rather than as a binary response. This would also enable longer term outcomes to be monitored when patient follow up is incomplete.

ACTION

- 12. Members of the LAG are asked to consider the development proposals for the CUSUM monitoring of liver transplantation and endorse.

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