Haematology Completely Automated Using an Innovative Dual HST Transportation System, Meru Work Area Manager and Molis Software

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The merging of two community laboratories and the need to upgrade equipment offered the opportunity to improve workflow and productivity. The introduction of a new system based on dual HST Transportation modules linked in series provides the means to completely automate full blood count (FBC) analysis including reflex testing. Additional efficiencies have been achieved with a new hematology work area manager, Meru that is primarily used in microscopy. Molis software handles data from these two elements and acts as a single interface to the laboratory information system (LIS). Significant benefits have been achieved.

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INTRODUCTION

The merging of two community laboratories resulted in a combined full blood count (FBC) workload of 2500-3000 specimens per day. This workload, along with the need to replace ageing analysers, warranted an investigation into the benefits of introducing a fully automated haematology system.

Many areas of sample processing had been enhanced to eliminate inefficiencies but further significant gains were only possible with major hardware and software changes. Prior to the merge, the individual laboratories could not justify the high cost of a fully automated system.

With increasing costs and often-static reimbursement, laboratories are continually seeking improved productivity. While laboratory scientists are aware of the benefits of automation, solutions can be expensive. Any major change such as described in this article requires thorough cost benefit analysis and careful decision making.

The old system and its disadvantages are described, followed by a summary of the reasons why change was considered necessary. An analysis of the workflow by Sysmex Singapore Pte Ltd. with the help of Roche Diagnostics New Zealand, provided the necessary data for the proposal of a new system aimed at improving productivity.

A relatively new and innovative approach was proposed and a totally new work area manager was developed to complete the package. This fully automated system, its introduction and the benefits achieved after the first year are described in this article.

SPECIMEN COLLECTION AND REGISTRATION

Diagnostic Medlab has 90 collection rooms situated in the greater Auckland region. The sample tubes are all bar-coded at collection. Most of the rooms are equipped with a computer, which contains a copy of the main laboratory patient database. The patient information is accessed or entered into the computer and registration information such as test requests, clinical details and doctor information is added. Due to the high cost of having all these rooms electronically connected to the main laboratory LIS (Sysmex Delphic Ltd.), the registration information is transferred to the laboratory via a PDF bar-code label which is attached to the reverse side of the request form. An attached printer produces the PDF bar-code along with specimen bar-code labels (code 39). These specimens are also sorted into haematology and biochemistry bags by the collection staff.

Specimens are delivered to the laboratory by courier from the collection rooms where they pass through the specimen reception department. In order to avoid photocopying request forms for departments, the forms are scanned through duplex Kodak 3500 scanners (Eastman Kodak Co.) which record an image of both sides of the form for future reference. The PDF bar-code is read and the request is automatically registered into the LIS. Approximately 50% of the requests are registered in this manner leaving the remainder to be registered by data entry staff from the imaged request forms. After the forms have been scanned, the specimens are released to the departments.

DESCRIPTION OF THE OLD HAEMATOLOGY WORKFLOW

Fig. 1 shows the old workflow. Once samples have been delivered to the haematology department, the bar-code on the sample tube is scanned to determine what tests are required. If an erythrocyte sedimentation rate (ESR) is requested the sample is diverted to one of four analysers before being tested for FBC. Samples requiring only an FBC were sent directly to one of five stand-alone analysers equipped with automated samplers.

The specimens were tested for FBC in random order but after sampling, they were racked in batches of 20 and the result printouts were matched to the specimen rack. An interface program checked these results for analyser flags, which required reflex actions. After checking quality control the results were released to the LIS. Specimen racks plus matching results were sent to a computer station equipped with a bar-code scanner.

Here, the specimens were rescanned to allocate a storage number. At the same time a worksheet was produced which indicated whether a specimen was normal and could be released, whether it was significantly abnormal and required a blood smear or whether it required reviewing by a scientist. The LIS provided this information through the use of an algorithm of relatively limited capability. For those needing a review the scientist was required to enter comments on the results into the LIS or make a decision to have a blood smear prepared.

From the worksheet list, blood smears were prepared manually and stained on a semi-automated stainer. Approximately 22% of the samples had blood smears prepared and examined. Specimens were transferred to storage racks according to their pre-allocated storage number while the worksheet and result printouts were sent for matching to the bloods smears once they had been stained.

At microscopy a format in the LIS was used to perform a white cell differential if necessary and comments were added to the patient record. A senior scientist signed out these results before being reported by the LIS. After completion, the worksheets with accompanying result printouts were filed, as were the blood smears.

Disadvantages

The workflow as described had three significant disadvantages that together resulted in a labour intensive system.

1. Equipment

Many of the tasks were associated with the lack of automation, which required staff to handle specimens on numerous occasions. Loading and unloading multiple analysers, manual pre-dilutions and sampling of reticulocyte counts, storage number allocation, blood film preparation and staining are typical examples.

2. Paper dependence

In order to make accurate and meaningful comments on blood smear findings microscopists require scatterplots in addition to the numerical results. The inability to provide this information electronically at the microscopy stations left the department dependent on paper result printouts and the use of worksheets.

3. Limited computer algorithm

Various functions of the algorithm were divided into two areas. Rules associated with analyser flags and results requiring further attention were confined to the interface

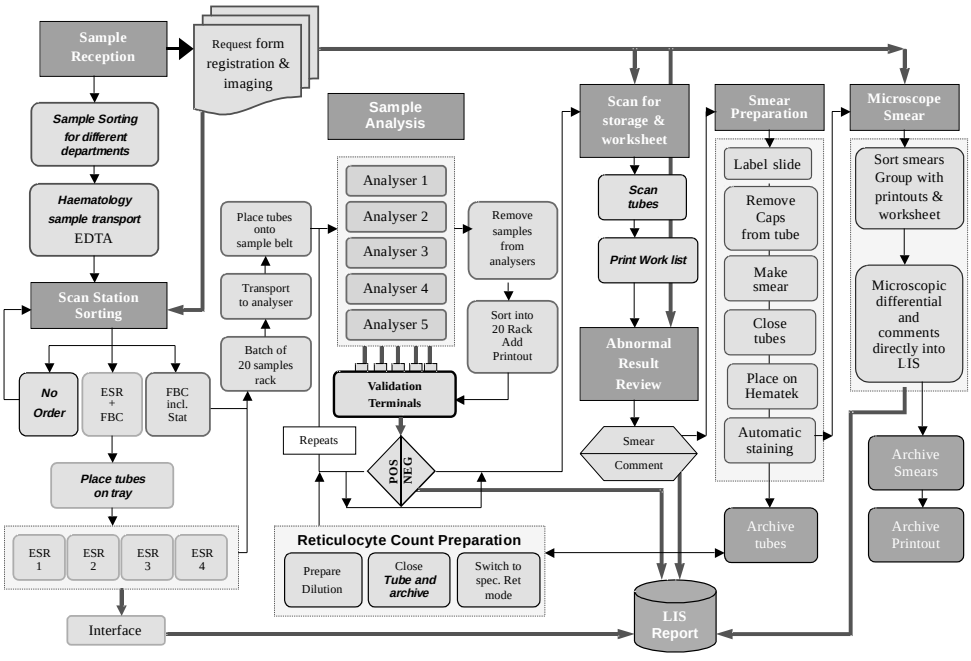

Fig. 1 *Workflow of the old system*

program while the rules requiring database information, such as patient or doctor details, were located in the LIS. This duplicity meant that samples failing the rules had to be checked twice. It should be noted that the algorithm had the potential to be developed further but it was considered there would be limited gain from pursuing that approach. In addition, manual review of a significant number of results led to variation in decision making regarding blood smear preparation.

Reasons for change

The key reasons are summarised below.

- The FBC analysers were old and increasingly unreliable.
- The workload had risen substantially with the merge of two laboratories.
- A streamlined, efficient, automated workflow was required to cope with the workload.
- There was a need to eliminate boring and repetitive tasks for staff welfare.
- Staff savings or reallocation were beneficial due to workforce shortages.
- A desire to improve quality.
- An aim to achieve a paperless system – a microscopy work area manager.
- A need for a system that provided spare capacity for growth.

WORKFLOW ANALYSIS

In order to ascertain workflow patterns samples were counted in 10 min blocks as they arrived at the laboratory and into the haematology department. The data was entered into a Sysmex analytical simulation tool (CoSiMo) to determine the number of analysers required to test the workload in a working day. (***Fig. 2***) The majority of samples are received between 11am and 7:30pm with a maximum of 704 samples in one hourly period. CoSiMo predicted that three routine analysers (XE-2100L) would complete testing 2500 samples by 7:30pm at an average time/sample of 7:42min. The maximum sample pooling (awaiting testing) was approximately 60 at 1:20pm and only 20 at 7:20pm.
Workflow procedures were documented to identify tasks that were essential to the laboratory service and those that could be made more efficient by a Sysmex solution.

PROPOSED CONFIGURATION

A complete overview of the new system can be seen in ***Fig. 3***. A relatively new concept of a routine HST line linked to a second expert HST line was proposed by Sysmex. The routine line, consisted of three Sysmex XE-2100L analysers and the expert line, consisted of one Sysmex XE-2100, automated hematology analyser and two Sysmex SP-100, automated slide preparation units. Using this configuration, a major goal was considered attainable. The goal was that all testing on a sample would be complete when the sample reached the stockyard of the expert line.
The dual lines also have a rack bar-coding system whereby the specimens within a rack are recognised by rack number and position within the rack. This information is used to provide more efficient testing in the expert line, as racks will be moved to the appropriate analyser and positioned at the sample requiring the reflex testing.
It was proposed that all samples would be tested in the routine line for FBC and Differential (standard profile in New Zealand). Reflex testing, ordered by a rules based algorithm would be performed in the expert line by the XE-2100 and/or one of the SP-100s. The reflex tests included repeat FBC, nucleated red cell count, reticulocytes, platelet count by fluorescence and blood film.
The only manual intervention required with the above system is for medical emergencies, micro samples and those requiring dilution, testing at 37°C or checking for lipaemia. Other samples do not need further handling other than to place in storage racks. The rack and position numbers are used as storage identifiers eliminating the need to rescan the sample tubes.
The hardware configuration is supported by Sysmex Molis

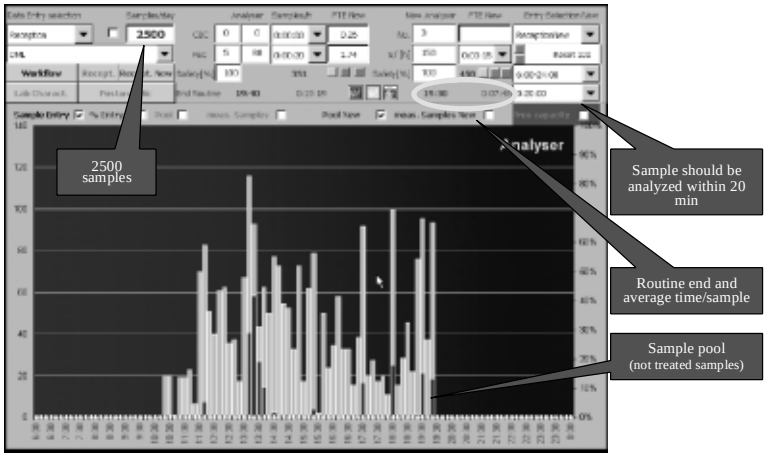

Fig. 2 *CoSiMo analysis of sample data*

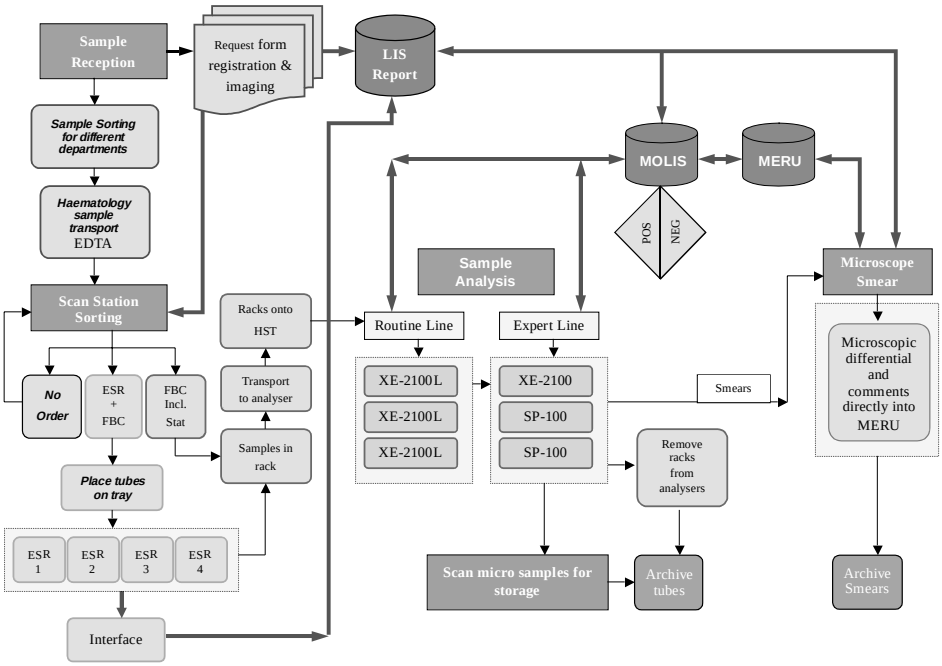

Fig. 3 *Workflow of the new system*

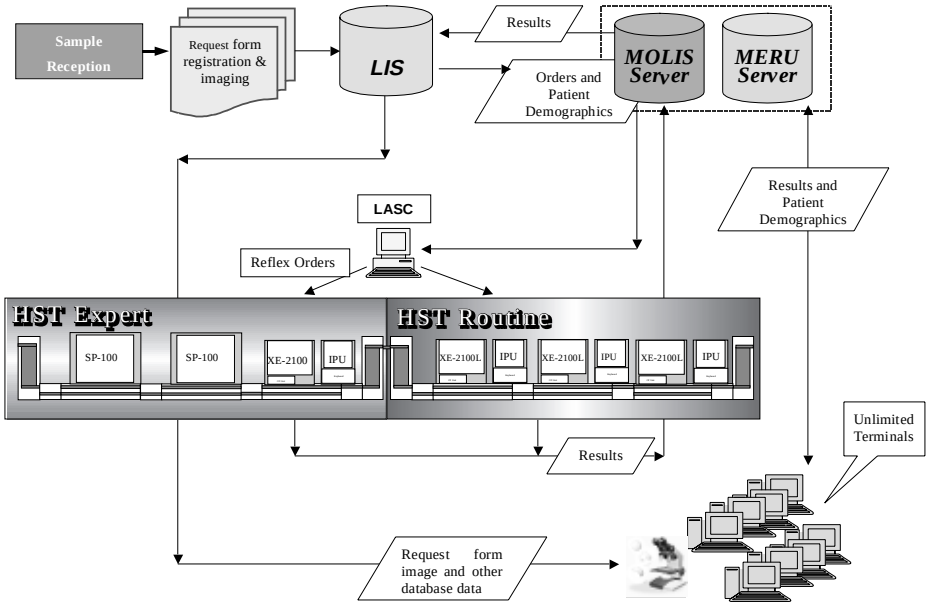

Fig. 4 *Dataflow*

computer software, which communicates information between the LIS and the Laboratory Automation System Controller (LASC) for the two HST lines. It also acts as a repository for sample results and patient demographics; information that is used in the rules based algorithm and is accessed by the microscope work area manager, Meru. A data flow diagram is seen in ***Fig. 4***.

Test request orders and patient demographics are sent from the LIS to Molis where the information is passed to the LASC, which communicates with the routine line. A full blood count and white cell differential is ordered and performed on all samples passing through the Routine line. Molis receives the results and applies the algorithm rules utilising patient demographics as well as previous test results. Negative (normal) results have an automatic comment added and released to the LIS for reporting. Positive (abnormal) results are either released with specific comments related to the mild abnormalities found or

reflex tests are generated.
While samples are being transported to the expert line, reflex test orders are sent from Molis to LASC and then to the expert line controller. As a consequence, all additional or specific tests such as a reticulocyte count (reflex or requested) can be performed prior to the sample reaching the final stockyard.
The third component of the Sysmex proposal, the microscope work area manager, presented the greatest risk as the laboratory's requirement for 20 client stations ruled out the use of the Sysmex SIS work area manager product. It was proposed that Sysmex Delphic, our LIS computer provider, would work with Diagnostic Medlab to develop Meru, a new web browser based product.

Installation

Diagnostic Medlab accepted the above proposal and an installation plan was formulated with Roche Diagnostics NZ Ltd. to install the equipment and software in three stages.
Stage 1: The five existing analysers were replaced in October 2001 with four stand-alone XE-2100 analysers (three XE-2100L models) each with automated sample handling units. This alleviated reliability problems and allowed the staff to become familiar with the new technology.
Stage 2: In December 2001 the XE-2100 analysers plus two SP-100 slide maker stainers were incorporated into the two HST lines. The Molis software was also installed at this time. As an interim, while Meru was being developed, paper printouts were produced on all positive samples.
Stage 3: The first version of the Meru was installed in May 2002.

DISCUSSION

Review of performance after one year

The blood film preparation rate has been reduced from 22.3% to 17.3%.
In September 2001 the number of FBC requests completed by 5pm averaged at 36% in contrast to the September 2002 figure of 69%. New turn around time (TAT) measurements have been instigated which show that 86% of FBC's are completed in 2hrs from registration. No previous comparable figures are available. The average testing time for a rack of ten samples taken from the start yard of the routine line to the stockyard of the expert line is 23 minutes.
Staff numbers have been reduced by 7.4 full time equivalents (FTE). This has been achieved through redeployment and natural attrition. Staff costs have fallen by 4.8% measured as year to date (YTD) September 2002 versus YTD September 2001. The net reduction is further enhanced when annual wage increases are taken into account.
Productivity, as measured by the number of tests per FTE, has increased 22%.
There has been an 89% reduction in paper costs for the total Haematology department.

Benefits

The routine and expert dual HST system introduced a high level of automation especially in sample handling and blood film preparation. The use of Sysmex XE-2100 analysers sampling at 150 samples per hour reduced the number of FBC instruments from five to four and the need for only one instrument with full testing capabilities reduced the overall capital cost. Reliability of the equipment has been very good.
Comprehensive rules based decision making resulted in consistency of automatic reporting and film making criteria. There has also been an improvement in the quality of the blood films with more consistent preparation, staining and labelling.
Meru, the Sysmex Delphic haematology work area manager, provides the functionality that the microscopists need to perform blood smear examinations in a paperless environment. In addition, it records a comprehensive audit trail of all actions relating to each sample which enables the laboratory to fulfill International Accreditation New Zealand (IANZ) quality assurance requirements in the absence of the previous paper system.
In totality, the Sysmex solution has given the laboratory a streamlined, efficient and highly automated workflow by eliminating numerous manual procedures present in the previous workflow. Staff numbers have been reduced and morale has risen now that the boring and repetitive tasks have been removed. While reliability and accuracy have been enhanced the most significant outcomes have been the improved productivity and turn around times.

Reference

1) *Macdonald AJ, et al.: The Impact of an intergrated haematology screening system on laboratory practice. Clin Lab Haematol, 18 (4): 271–276, 1996.*