TLA – The 'Lean' Alternative

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Demonstrating how Lean work cells deliver faster turnaround times, higher productivity & efficiency, increased flexibility, improved space utilisation and improved quality.

The management system referred to as 'Lean' originated in Japan in the 1950's and was developed by Toyota over subsequent decades. Over more recent years the same principles have been applied to almost all manufacturing, commercial and public sectors, including Healthcare. To illustrate the widespread interest and availability of information on Lean, a search of amazon.co.uk using the words 'Lean Thinking' produced a list of 948 books, whilst a similar exercise with Google revealed 1,480,000 results for 'Lean Manufacturing', 318,000 for 'Lean Healthcare', and 398,000 for 'Lean Pathology'.

Given the widespread availability of scholarly theoretical and practical information on Lean, it is not our intention to replicate the theory in this text other than to provide a brief overview of Lean where appropriate to enable readers to follow and understand that which is described. The main purpose of this 'article' is simply to provide a practical approach towards Lean implementation within the context of a clinical laboratory setting. Drawing on experiences from our own Lean implementation programme it is hoped that the reader will gain a valuable insight into the 'do's and don'ts' of applying Lean theory and practice to the laboratory workplace.

Improving quality, increasing staff productivity, and reducing costs are challenges typically driving clinical laboratories towards higher levels of automation as a solution. Particularly in the Blood Science domains of clinical chemistry and haematology, there is a bewildering spectrum of equipment available, ranging from discrete automation (across the pre-analytical, analytical, and post-analytical phases), through modular systems linked by track, to fully robotic total laboratory automated solutions.

Lagging somewhat behind the widespread development of automated systems is the emergence of Lean, the theory and practice of which is readily applicable to the clinical laboratory. The focus of Lean is the elimination of waste in all its various forms and a variety of tools and techniques are provided to achieve this aim. By eliminating waste and optimising work processes, Lean achieves the same goals of improving quality, increasing staff productivity and reducing costs, BUT, at a fraction of the cost of deploying automated systems.

This is not to suggest that Lean is an alternative to automation per se, but rather as a methodology that may be used to guide the appropriate choice of equipment and its utilisation in the laboratory. In this article we will describe the approach taken by Path Links to develop a 'Total Lean Solution' for the clinical laboratory.

Whilst a detailed overview of Lean is beyond the scope of this short text, some important principles are described:

. As previously mentioned, the elimination of waste is the main focus of Lean. There are typically 7 wastes described; Defects, Overproduction, Waiting, Transport, Motion, Inventory & Overproduction, whilst a further two are recognised, those of Underutilising People and 'Inappropriate' Automation. The target of Lean is to identify, eliminate or minimise all forms of waste that add no value (from a customer perspective) to the product or service provided.

. Value Stream Mapping is a critical tool in the Lean armoury. Its purpose is to accurately capture all activities and information flows in a process by direct observation and data collection, thereby differentiating between 'what is actually happening', as opposed to 'what we think is happening'. In this way we are able to identify all non value adding steps in a process and those activities that create waste. Their subsequent elimination will speed up the process (improve flow), optimise activity, improve quality and reduce costs.

. Flow is the continual movement of products or services through a process, avoiding 'stop-start' interruptions that cause unnecessary delays and bottlenecks. It is also much easier to rapidly identify problems occurring within a process where continuous flow is achieved.

By far the biggest wastes typically found in the laboratory are associated with poorly designed processes and layout.

Processing samples in batches may be intuitive and often compounded by the type of equipment available in the laboratory. For example, large laboratory centrifuges typically have a capacity for centrifuging up to 64 standard tubes at a time. During busy periods it would seem sensible to run the centrifuge at maximum capacity. However, what this creates is a 'batch and queue' process that will have an adverse impact on laboratory productivity, analytical capacity and processing time by inhibiting flow. Taking the centrifuge as an example, to prepare 64 tubes would take approximately 25 minutes to load (allowing 20 seconds to de-bag, check, and bar-code label each sample), and a further 15 minutes centrifugation and unloading time. At best, it would take a minimum of 40 minutes from sample receipt to presentation to the analytical phase. At peak times, and where multiple centrifuges are used, this will result in large batches of samples being simultaneously loaded onto the analyser. This in turn may lead to further inefficiencies should analytical capacity be exceeded. Worse still, the routine perception of an analyser's inability to cope with peak demand increasingly fuels the desire for higher capacity and faster throughput analysers with greater levels of automation.

As an alternative, we have applied Lean methodology to re-design the pre-analytical process and improve sample flow. Standard laboratory centrifuges have been replaced with smaller capacity (8 tube) rapid centrifuges; the rationale being to force a reduction in maximum batch size (from 64 tubes to 8) and to shorten the spin time (from 10 minutes to 3). Applying the same criteria it would take just 3 minutes to load and 4 minutes for centrifugation and unloading, making samples available for analysis after just 7 minutes. In this way sample analysis commences 33 minutes earlier than with the 'batch and queue' process example. Importantly, the significantly reduced batch size being presented to the analytical platform ensures a smooth continuous operation well beneath the analytical capacity threshold of the analyser.

The above example not only shows the benefits of improving flow but also illustrates the '9th Waste of Lean', that of automating a bad process. A decision for increasing automation in the absence of fully understanding the entire end to end process, and implementing process improvement, is a bad one. Quite simply, automating a poor process only serves to automate waste and will often lead to higher expenditure than is required.

From our own experience of implementing Lean, there are further specific examples. In Histopathology, where Path Links operates one of the largest histology services in the U.K. processing in excess of 60,000 surgical specimens per year, the volume of activity led to a 'pre-Lean' decision to purchase a high capacity automated slide staining system. Following Lean process re-design, the automated stainer was quickly identified as a 'bottleneck'. As a high capacity batch processor it effectively impeded specimen flow through the laboratory causing adverse delays. The system was subsequently replaced by a much simpler linear continuous flow system at a fraction of the cost of the automated batch processor. But probably the best, or worst, illustration comes from an early decision to introduce pre-analytical automation into our laboratories. Based on perceived needs and benefits rather than an objective understanding and analysis of process, we commissioned 4 systems (purchase price £800,000, revenue costs £80,000 per year). Post Lean process analysis has demonstrated that the pre-analytical equipment contributed to unnecessary delays and bottlenecks proving less efficient than an optimised manual Lean process. As a result we have already embarked on a process of removing the equipment from our laboratories.

A further important factor for consideration is the layout and space utilisation of the laboratory environment. A well designed and properly configured laboratory delivers significant benefits in terms of capacity, productivity, and workflow. The experience from manufacturing industry is that a U-shaped Lean work cell provides an optimum configuration, minimising walking distance and allowing different combinations of work tasks to be undertaken by the cell operator. Lean Work Cells are designed to eliminate waste, improve flow and help optimise material, people and information flows. Communication is usually enhanced, because operators work closer to each other and, through improved visual control, operators can see and manage the entire process.

Through achieving and maintaining efficient continuous work flows, Lean work cells deliver shorter cycle times (turnaround times), higher productivity & efficiency, increased flexibility, improved space utilisation, and improved quality.

As applied to Blood Science laboratories, analytical cells will typically bring together all routine automated equipment accounting for 80%+ of laboratory activity and will include Clinical Chemistry/Immunoassay, Haematology and Coagulation (Fig1).

All other activity e.g. microscopy, should be located to the periphery of the laboratory or co-located as close as possible to the analytical cell. Data management and validation work stations may similarly be co-located but away from the analytical cell.

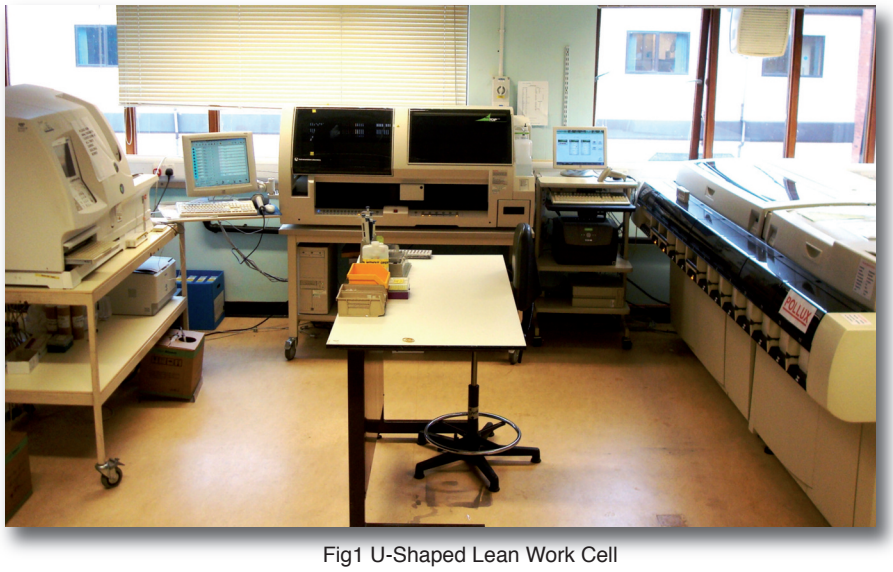

Fig1 U-Shaped Lean Work Cell

Allied to the development of a Blood Science analytical work cell is the requirement to simultaneously address layout and location issues in specimen reception and blood transfusion laboratories. Both functions should, again, ideally be co-located or within close proximity to the core Blood Science laboratory.

The figure below illustrates a typical Lean layout configuration for a Blood Science clinical laboratory (Fig 2)

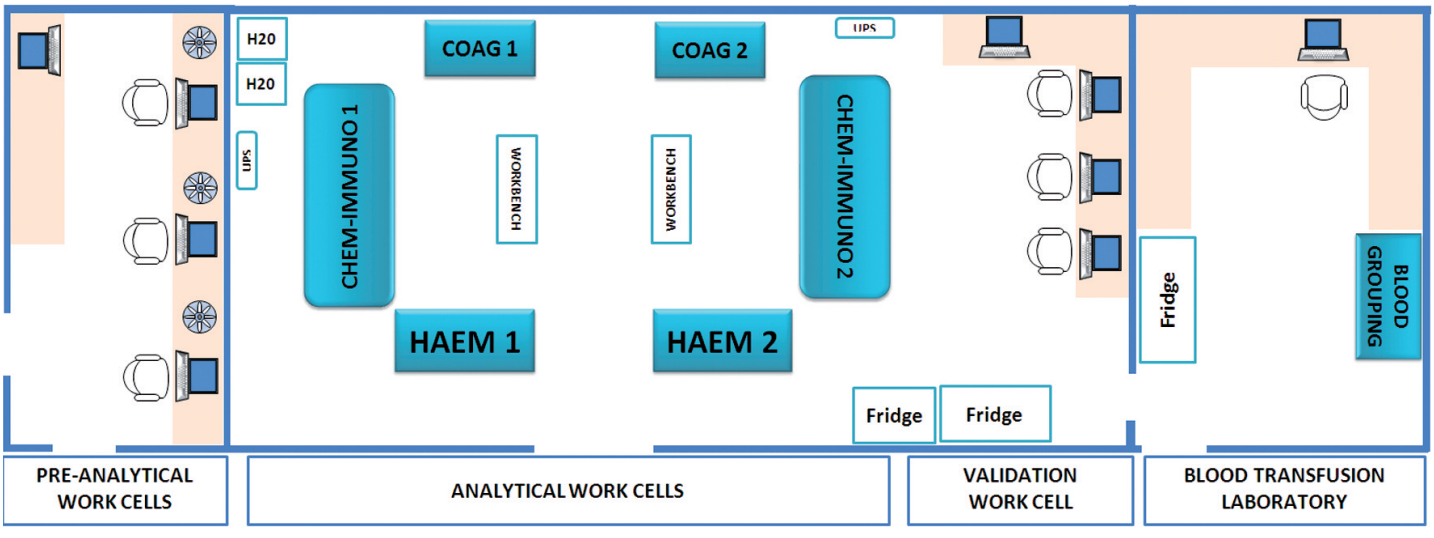

Fig 2 Lean Blood Science Laboratory Layout

The optimised layout achieves perfect 'line of sight' to ensure appropriate visual control of operations and rapidly identify and address any issues impacting on work flow. Travel distances for staff are minimised and the co-location of equipment allows a single operator complete control over the work process, distributing incoming samples quickly to the next available analyser to minimise processing time and achieve faster throughput.

Analytical equipment is free standing or on trolleys to allow rapid reconfiguration in achieving an optimised layout. This differentiates the Lean configuration from automated tracked systems. In the design of a Lean laboratory, achieving optimised layout, work processes and sample flow is of primary importance which, in turn, is used to inform the selection of appropriate automated equipment. In other words, automation is selected to 'fit the process' and not the other way around. Whilst highly automated tracked systems may to an extent be configurable, they largely dictate space utilisation and work processes to 'fit the automation'. In the absence of fully understanding the entire laboratory process lies the inherent risk of 'automating a bad process'.

In our laboratories, Lean is being applied to all work processes across the pre-analytical, analytical and post-analytical phases to achieve a total Lean laboratory solution. For example, the same Lean work cell philosophy has been applied to the pre-analytical process (Fig 3). Here, a single operator undertakes all pre-analytical functions in a single process from de-bagging, sample & request checking, bar-coding, data entry, sample racking and centrifugation. The layout of the work cell is standardised so that each work cell is identical. Samples are processed one at a time achieving 'single piece flow' on a 'first in first out' basis. Problem samples are taken out of the process so as not to interrupt the work flow. The entire process is designed to optimise throughput and eliminate opportunity for error.

Fig 3 Lean Pre-Analytical Work Cell

In our experience, the development and deployment of pre-analytical work cells has led to dramatic improvements to laboratory efficiency and productivity. Hospital inpatient turnaround times have improved by 40% and median turnaround times for emergency department requests down to 14 minutes for haematology (CBC) and 29 minutes for chemistry (U&E/Troponin I). The completion of routine daily work has been reduced by over 2 hours leading to a reduction of 2 FTE from the evening work period.

A benefit of work cells is that they are scalable to match variable workload activity throughout the day. During quiet periods only a single work cell will be operational increasing to maximum deployment at peak times. From our data, the throughput of each pre-analytical work cell is 60 per hour for manual data entry and 240 for electronic order requests. At peak times, utilising 3 work cells to ensure smooth & continuous flow, a rate of delivery of between 45 -180 samples to the analytical work cells is achievable every 15 minutes.

Taking the illustration further, a scenario whereby 300 samples are received into the laboratory, the operation of three pre-analytical work cells would deliver 30 CBC samples every 10 minutes (assuming manual data entry) to the analytical work cells. With a total analytical capacity of 240 samples per hour from two analysers, the total processing time for 30 samples would be 7.5 minutes; these being processed before the next delivery of 30 samples from the pre-analytical work cells. By ensuring a smooth and continuous flow of samples to the analytical work cells, the entire 300 sample workload is completed in just 1 hour 50 minutes from time of arrival with first result availability after only 12 minutes (Fig 4). Importantly, the analytical capacity of the analysers is not exceeded with both systems running at 75% of total capacity throughout the period.

PROCESS TIME (minutes)		10	20	30	40	50	60	70	80	90	100	110
PRE ANALYTICAL	Cell 1 Samples Processed	10	10	10	10	10	10	10	10	10	10	
	Cell 2 Samples Processed	10	10	10	10	10	10	10	10	10	10	
	Cell 3 Samples Processed	10	10	10	10	10	10	10	10	10	10	
	Total Samples Processed	30	30	30	30	30	30	30	30	30	30	
ANALYTICAL	Work Cell 1											
	# CBC	15	15	15	15	15	15	15	15	15	15	15
	Minutes	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
	Work Cell 2											
	# CBC	15	15	15	15	15	15	15	15	15	15	15
	Minutes	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5

Fig 4 CBC Pre-Analytical & Analytical Process Flow

Conclusion:

The adoption of Lean principles and methodologies provides significant improvement opportunities for the clinical laboratory. Not least to address the challenges of improving quality, increasing productivity and reducing costs, Lean provides a systematic and analytical approach to achieving optimised work processes, laboratory design, layout configuration, and appropriate equipment choice.

[1] Path Links is a Clinical Division of Northern Lincolnshire & Goole Hospitals NHS Foundation Trust providing a comprehensive range of clinical laboratory services to 7 hospitals and a population of over 1 million inhabitants in and around the County of Lincolnshire, UK

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