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Technical Note

Adapting lean to histology laboratories

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Abstract

Histology laboratories (histolabs) can increase productivity and reduce turnaround time and errors by using any one of several available management tools. After a few years of operation, all histolabs develop workflow problems. Histology laboratories handling more than 20 000 cases per year benefit the most from implementing management tools, as occurred in the 25 facilities summarized in this article. Discontinuous workflow, lack of "pulling" between steps, accepting unavoidable waiting times while working with small batches within work cells, and a workflow with an uneven rate of completion, are some of the adaptations required by the Lean system when it is used in histology because 70% of the tasks are manual and the flow has to be interrupted to add value to the pieces of tissue during tissue processing, no matter how short that step is. After all these adaptations are incorporated, the histolab becomes as "Lean" as it can be, and the qualifier is also a recognition of the effort and personnel involvement in the implementation. Given its service nature, productivity increments do not expand the histolab customer base and could lead to staffing reductions. This is one of the causes of reluctance by some employees for implementing these techniques which are mostly driven by cost reductions sought by insurance companies and administrators, and not necessarily because of a real medical need to reduce the turnaround time. Finally, any histolab wanting to improve its workflow can follow some easy steps presented here as a guide to accomplish that objective. These steps stress the need for the supervisors to insure that the personnel in the histology laboratory are being paid at a comparable rate as other histolabs in the area.

Keywords: 5S; Six Sigma; Just-In-time; First-in-first-out; Lean; Work flow analysis, Henry Ford production system

1. Introduction

Until 1909, when the first automated clock-controlled tissue processor with a basket carrying pieces of tissue between 7 stations was invented by Arendt, only 3 other previous technological feats had any real impact on the histotechs' (histology technologists and technicians) productivity; namely, Leuckhart's metal embedding rectangles in 1881, Minot's rotary automatic microtome in 1887 and Borrmann's staining rack for multiple slides in 1894 [1], all of which had only marginal effect on productivity. The first automated tissue processor, primitive as it was, not only served as the blueprint for better instruments to come (starting with the Autotechnicon in 1945), but also reduced by half the time needed for tissue processing (TP), improved quality by introducing automated consistency, and divided the whole histolab operation into 2 well defined periods and types of operations, that is, those performed before and after TP. Advances after 1945 were aimed at obtaining improved infiltration quality and a marginal increase in productivity through allowing shorter protocols with larger batches.

It was not until the late 1980's that the introduction of microwave (MW) technology allowed very short TP periods, but the time required to complete the pre- and post-TP tasks remained completely independent of how fast the tissues are processed leading to a workflow paradigm. To obtain the fastest histolab operation, TP was required to last approximately the same time as the pre-TP tasks. This was obtainable only with a maximum of 15 cassettes processed in just 0.42 hours after 0.52 hours of pre-TP tasks followed by 1.05 hours of post-TP tasks for an overall output of up to 15 finished slides every 2 hours [2]. This can be accomplished using a small manual and inexpensive MW oven, such as the TBS SHUR/Wave from Triangle Biomedical Sciences, Inc (Durham, NC), permitting a viable throughput workflow alternative to the one offered by more expensive automated throughput tissue processors such as the Xpressx120 or the Xpressx50 from Sakura Finetechnical

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Co (Tokyo, Japan), with a production of up to 40 finished slides every 5 hours.

Besides improvements in TP the histolab has benefited greatly by other automated instruments, especially stainers and coverslippers, allowing those tasks to be completed 2.3 and 2.7 times faster than manually, respectively [3]. Other instruments, including cassette writers and slides etchers have also improved the workflow and at present there is an automated embedding instrument, the Tissue-Tek AutoTEC (from Sakura, Japan), able to cast 120 blocks per hour, which is twice the average productivity for manual embedding [4]. The Automated Tissue Sectioning System AS-200 (from Kurabo Industries Ltd, Osaka, Japan), still being assessed, is capable of producing 200 dried slides from as many as 20 blocks every 2 hours which, even if 4 times slower than the average manual sectioning productivity [4], has been proven to be more adequate for the virtual microscopy Whole Slides Imaging systems' focusing capabilities because it consistently produces thinner and flatter sections than manual sectioning [5].

A histolab equipped with the latest automated instruments available has little options left to further improve its workflow other than using its resources and personnel in the most rational and effective way possible. This is accomplished by turning to recognized management techniques. How to use those management tools for improving the histolab workflow is the subject of this article, which includes a historical account of the methods, examples of the application of some of the techniques and a general recommendation on how to improve the workflow of any histolab.

Finally, mentioning manufacturers and their instruments or management methods in the text does not constitute personal endorsement, just relevant examples of what is commercially available.

2. The evolution of some management techniques

By 1895 Gustavus Swift had already perfected a "disassembly" line that allowed him to brag that, "except for the squeal," everything else from the cattle at his Swift & Co Chicago-based slaughter house was transformed into a derivate product, with his plant being the first able to move the carcasses hanging from a conveyor belt between butchers to be quickly reduced to their smaller components. Inspired after observing this extraordinary productivity achievement, Henry Ford, in a sort of "reversed engineering" process, conceived an "assembly" workflow where all the interchangeable parts of an automobile could be assembled by moving a chassis along several fixed stations and constantly adding parts to it. This type of assembly line was introduced by Ford in 1908 to manufacture the Model T in the Ford Piquette Avenue plant and, later, in 1913, in the Highland Park plant, both in Detroit, MI. This system allowed him to produce 1,000 "Tin Lizzies" daily or 1 running out from the factory close to every 2 minutes. By doing so, Ford maximized productivity starting a world revolution in manufacturing and creating the Ford Production System (FPS). Everything started then and in the 100 years since all efforts have been aimed at improving the management methods to increase production and lower costs, the first being the analysis to optimize the workflow. Although there are no references that Frederick W. Taylor ever was in contact with Henry Ford, the great precision of Ford's conveyor belt operation was made possible by the time and motion studies pioneered by Taylor. The best example perhaps of workflow analysis and optimization came to be in January 1940 when Charles Sorensen, using all his expertise with the FPS, designed the Ford Motor Co factory at Willow Run, near Ypsilanti, MI, which was able to produce 1 B24 bomber per hour as part of the US war effort during WWII.

The study of the turnaround time (TAT), so familiar today, became another management tool in 1926 with the introduction by the Germans of the concept of *Takt production*, derived from the word *Taktzeit* meaning timing, speed regulation, rhythm, music beat, which linked for the first time production with customers' demand [6]. The Takt production was used by Germany during WWII and was shared with Japan as a production method that was later transformed in the late 1940s into the "Just in Time" (JIT) system that changed the traditional "supply-and-demand" paradigm into a more efficient model of "demand-and-then-supply." [7] This became part of the Toyota Production System (TPS) in the mid 1950s. Tack time is at the heart of Value Stream Mapping [8] that also became a Lean tool, is equivalent to workflow and has been used to design work cells [9].

D Edwards Deming in 1933 created the control charts and from June to August of 1950 trained hundreds of Japanese engineers introducing them to the Quality Control (QC) and the Total Quality Management concepts, exemplified by his "14 principles and 7 deadly diseases" of management. This won him the title of "father of the Japanese post-war industrial revival," his teachings allowing Japanese quality to equal that of the West in 1974 and to surpass it ever since [10].

Also in 1950, Eiji Toyoda visited the Ford factory at Dearborn, MI, where 8000 cars were produced daily, and concluded that the FPS was inadequate for Toyota, which was only producing 2500 autos annually. He was not impressed because he concluded that there was too much waste intrinsic to the FPS but, on the other hand, appreciated the way in which the Piggly Wiggly Supermarkets reordered and restocked their supplies based on the customers' demands. These 2 observations were decisive in developing the TPS based in an unrelenting commitment to waste elimination, the implementation of the JIT workflow and maximizing quality through effective employee participation.

The "5 S" management tool, now an integral part of the TPS, consists of a series of steps part of the Virtual