The Management of Surgical Pathology by Theory of Constraints

Punpet Noimay[1]
Supinda Koonmee[2]*
Anongrux Thripsupa[3]
Sopa Pochai[3]

Abstract

This research aims to study the management by Theory of Constraints (TOC) in surgical pathology, Department of Pathology, Faculty of Medicine, Khon Kaen University, to improve the on time delivery of the diagnosis (within 14 days from receiving specimens). The research methodology included interviews, process identification and work practices which have been adjusted. The 14,000 surgical specimens were collected and analyzed from February 2008 to January 2009. The constraint in this process was found in tissue diagnosed by Pathologist. Paired sample t-test shows that after implementing the Theory of Constraints in surgical pathology, the on time delivery increased significantly, from 80.64% to 92.34% ($p < 0.05$).

Keywords : Management, Theory of Constraints, Surgical Pathology

Introduction

Surgical pathology is the diagnostic service of tissues or specimens taken from patients. This service has been a major part of the academic service given by the Department of Pathology, at Srinagarind Hospital, for almost 40 years now. Usually, surgeons are the ones who make appointments as a post-surgery follow up with patients. In some cases, the appointments are long-term treatment schedules for patients with malignant tumors or cancer. The diagnosis results are, in general, due within two weeks; however, out of the 1,200 tissue samples collected, up to 30% of the diagnosis report were not delivered on time. This resulted in the postponement of treatment schedules which wasted the patients' time, money, and sometimes even affected their health.

[1] *Scientist, Department of Pathology, Faculty of Medicine, Khon Kaen University*
[2] *Associate Professor, Department of Pathology, Faculty of Medicine, Khon Kaen University*
[3] *Officer, Department of Pathology, Faculty of Medicine, Khon Kaen University*
**Corresponding author, e-mail : s_koonmee@yahoo.com*

The Department of Pathology, therefore, tries to apply the Theory of Constraints (TOC) to improve the on time delivery of the diagnosis. The on time delivery rate after implementing the theory was then compared to the standard (14 days). The Theory of Constraints is the work process improvement theory by applying the thinking process which involves problem solving and decision making (Education Quality Improvement Project , 2006) in every process, whether it is a manufacturing process or a business process. Any machine or unit that plays the most critical role in slowing down the process are the determination of process duration, and is called a Constraint or a Bottle Neck. As the name implies, a Bottle Neck is naturally the narrowest part of a bottle which determines the water flow rate. Therefore, speeding up other processes, other than a Bottle Neck, would not improve process duration of the whole system. The other benefit of TOC method is that it tries to improve the efficiency of the system as a whole rather than trying to improve only a specific process of the system (Goldratt, 1990). The processes in surgical pathology include: 1) specimen collection and registration 2) specimen gross examination 3) paraffin embedding 4) glass slide preparation 5) staining and preparing for diagnosis 6) microscopic examination by pathologist which may request for specific staining or immunohistochemistry study 7) report preparation and record in the Srinagarind Hospital database.

A surgical pathology process can be compared to a manufacturing process in which an appropriate design is required (Mohammad, 2006) in order to obtain the expected product (A tissue diagnosis report within the hospital network), which serves the needs of the service receivers or surgeons submitting the specimens. The Theory of Constraints was applied to improve the total cycle production planning (Monta, 2008) which is a system planning for the Constraint.

The study objectives are to apply the Theory of Constraints with surgical pathology, Department of Pathology, Faculty of Medicine, and to compare the standard delivery time (14 days) with the delivery time after applying the theory. The research result would help us identify whether applying the theory with such process is useful and can be used with other types of service process to improve their productivity.

Sampling and Methodology

This study focused only on tissue diagnosed by pathologists collected from the Department of Pathology, Faculty of Medicine, Khon Kaen University. The specimen collecting period was during a 6-month period prior to implementing the Theory of Constraints; February to July, 2008, and a 6-month period after implementation; August, 2008 to January, 2009. Samples in the study were from 14,000 tissue specimens which were regular surgical pathology specimens, excluding kidney biopsy, cholangiocarcinoma, and frozen section. Diagnosis quality was not considered because the study only aims to verify the effectiveness of the theory in improving the surgical pathology processes by adjusting work practices as well as monitoring and evaluating its effectiveness, after the implementation. Such evaluation was done through interviews with working staffs, by observation, and by data collection for statistical analysis, e.g. frequency, percentage, average, deviation, and paired sample t-test.

Results

Process in surgical pathology consists of steps shown in Figure 1, starting from specimen collection and registration to check the completion of the specimen receipt form with patient's record, matching with the specimen type. This process is followed by gross examination to section the infected tissue area for a direct microscopic examination later on. Then, the specimens were sectioned into approximately 3 pieces for paraffin embedding during the night. In the next morning, the embedded paraffin would be sliced at 3-5 micron. It was placed on a glass slide and then stained, to be ready for a diagnosis by a pathologist. Tissues diagnosed by pathologists would be sent to the registration unit to prepare for diagnosis reports and assign code of disease for specimen, which would ultimately be recorded into the Srinagarind Hospital database.

In the case that the specimen could not be diagnosed, further study would be conducted, e.g. research on patient's record, new specimen collection or specific staining technique, or brainstorming sessions between pathologists.

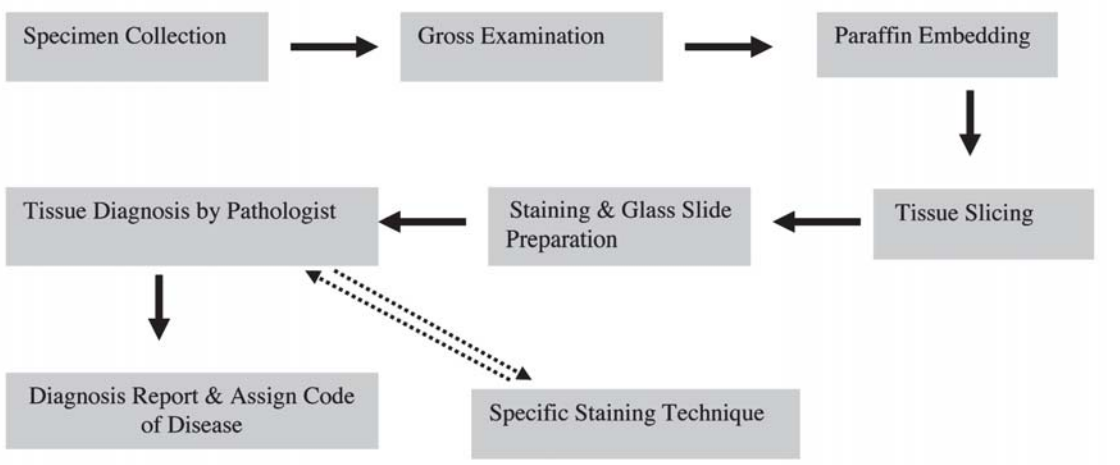

Figure 1. Process in Surgical Pathology

I. Results after implementing the Theory of Constraints in surgical pathology

All of the 5 steps from the Theory of Constraints were applied in the Department of Pathology as followed:

1. Identify the constraint in the existing surgical pathology process
2. Maximum utilization of the constraint
3. Focus on the constraint
4. Increase the potential and capability of the constraint
5. Verify the constraint, if there is any change occurred, start over from step 1

Step 1: Identify the constraint in the existing surgical pathology process

The constraint in the existing surgical pathology process can be identified by reviewing the productivity of each process. From Table 1, the constraint in the process was found in tissue diagnosis by pathologist, showing the average

diagnosis of 42 cases per day or 924 cases per month (22 working days), which was less productive compared to other processes receiving up to 1,200 cases per month. Therefore, we focused on this process and called it the 'Constraint' or 'Bottle Neck', because it is the least productive one which would become the process that determined the speed of the whole system. This constraint can be due to the fact that pathologists usually can contribute only 40 percent of their time in diagnosis work because they also have to give lecture and do research works.

Table 1. Productivity of Each Process

Process	Hours per Shift	Time in Service (%)	Operating Time per Day (Hours)	Operating Time per Day (Minute)	Persons/Equipment	Average Production Cycle (Minutes)	Products per Day
Specimen Registration (cases)	7	100	3.5	210	2	3	140
Gross Examination (cases)	7	100	7	420	4	20	84
Paraffin Embedding (blocks)	7	100	4	240	4	5	192
Tissue Sectioning (blocks)	7	100	4	240	2	3	160
Staining and Glass Slide Preparation (slides)	7	100	4	240	2	3	160
Tissue Diagnosis by Pathologist (cases)	7	40	2.8	168	10	40	42
Diagnose Report (cases)	7	100	3.5	210	2	2	210

This duty is in accordance with Khon Kaen University Announcement which states that all professors are required to perform the lecture duty no less than 50 percent of their total work contribution. In addition, they are expected to perform research work, educational management, laboratory quality improvement, and provide other educational services. Thus, with the existing record of the 40 percent contribution which resulted in 924 specimens diagnosed, if they are to meet the 1,200 cases target, they will need to contribute as much as (1,200 ÷ 924) × 40 = 51.9 percent on surgical pathology.

Step 2: Maximum Utilization of the Constraint

Since the tissue diagnosis by pathologists is the Constraint in the process, we tried to reduce pathologists' unnecessary tasks or reassign the tasks to other available parties, e.g. train other doctors within the department to monitor and supervise the gross examination and tissue sectioning; hence pathologists can spend more time on the diagnosis, increasing their time contribution from 40 to 50 percent.

Step 3: Focus on the Constraint

All units within the department were informed to prepare glass slides awaiting the diagnosis from pathologists. This was done in order to eliminate idling time of pathologists by putting up a board showing pool slides, shown in Figure 2, to display the status of the process before the Constraint (Daina, 2000). Everyone can monitor the situation of the pool slides awaiting the diagnosis. When the number of pool slides were low, there was a chance pathologists were idle. The wasted time by the Constraint meant the wasted time of the whole system. On the other hand, the high number of pool slides would drive the average delivery rate of the diagnosis up, forcing pathologists to team up and diagnose to speed up their delivery time which would reduce waiting pool slides. In addition, a complete patient record, an appropriate tissue selection during gross examination, and staining quality were also found to be useful for pathologists in giving a faster diagnosis.

Figure 2. Pool Slide, the arrow pointing at a large number of slides which pathologists team up and diagnose

Step 4: Increase the potential and capability of the constraint

Slides were assigned daily to pathologists; including 10 specimens each with extra slides allocated according to the number of diagnosis done by each pathologist in a day. Figure 3. shows the board displaying diagnosis records of each pathologist.

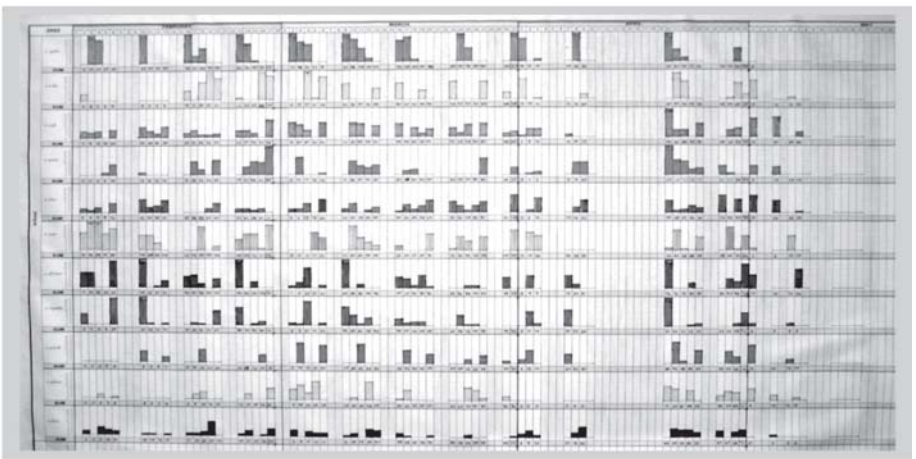

Figure 3. Diagnosis records by each pathologist in one day

In addition, warning cards, shown in Figure 4, were used to remind pathologists in their diagnosis time. The yellow cards would be given when specimens had been in process for 8 days since the registration date, whereas the red cards would be for specimens 12 days in process. There were total of 1,439 cards given, where there were 4 levels of diagnosis response which were given colored cards as follow:

Level 4: Fast Response (Diagnosed within 8-11 days since registration)

Level 3: Moderate Response (Diagnosed within 12-14 days since registration)

Level 2: Slow Response (Diagnosed within 15-20 days since registration)

Level 1: Very Slow Response (Diagnosed later than 20 days since registration)

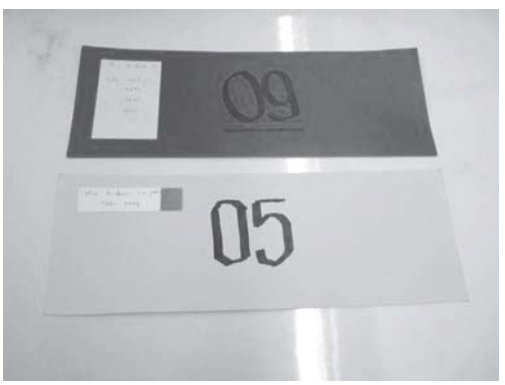

Figure 4. Warning ticket for a dely diagnosis

The diagnosis response level 3 and 4 yielded 70.80 percent on time delivery rate, whereas level 1 and 2 (slow and very slow response) resulted in 16.26 and 9.10 percent delayed diagnosis, respectively. Therefore, the plan for improving pathologist

efficiency was developed by starting a supervising program to encourage mutual learning among pathologists. This would greatly reduce the time spent on the microscopic examination on each slide, see warning card results in Table 2.

Table 2. Diagnosis response of pathologists after receiving warning cards

Level of Response	Specimens (patients)	Percent
1	131	9.10
2	234	16.26
3	380	26.40
4	694	44.40
Total	**1,439**	**100**

II Comparison of on time delivery rate before and after the implementation of the Theory of Constraints

Six months after applying the Theory of Constraints in surgical pathology process, the average on time delivery rate of the total 1,439 specimens increased from 80.64 to 92.34 percent (p value = 0.0003), as shown in Table 3.

Table 3. Percentage of the on time delivery rate before and after implementing the Theory of Constraints to the surgical pathology process

Sequence	Month						Mean $\pm$ SD
	1	2	3	4	5	6	
Before	78.48	80.75	80.24	83.12	85.98	75.29	80.64 $\pm$ 3.69
After	87.2	88.9	90.70	96.56	94.86	95.83	92.34 $\pm$ 3.93

Conclusion

In this study, the 5 steps of the Theory of Constraints were applied, without increasing the budget, focusing on solving the problem in tissue diagnosis process which is the Constraint. Boards were used to display process status for all parties to acknowledge and participate in assisting pathologists with their unnecessary tasks. In accordance with Richard and Zarbo (2007) regarding reducing the time wasted in surgical pathology, pathologists would have more time to spend on tissue diagnosis. Colored cards were also used to represent status of specimens with chances of late delivery, so priority could be given to those specimens, which would result in less late specimen delivery.

Results after implementing the Theory of Constraints showed a significant increase in the on time delivery rate from 80.64 to 92.34 percent ($p<0.05$). Such results were in accordance with Banlue (2001) regarding the application of the Theory of Constraints in home furniture factory. After identifying and improving the Bottle Neck, productivity increased 25 percent, operational expenses decreased 20 percent and inventory decreased 25 percent. It was therefore concluded that the Theory of Constraints was the appropriate theory for this application because of its flexibility. In addition, according to the study by Kadipasaoglu (2000) regarding the effect of protect capacity quantity and the position of the Constraint by using a simulation process, the result showed that protect capacity has a significant effect on production efficiency. On the other hand, when the Constraint position is closer toward the end of the process, there was more risk for the production to be stopped, due to lack of parts, than when it is closer toward the beginning of the process.

Although the Theory of Constraint was applied during the given time, the on time delivery rate in the surgical pathology process was not perfect. This was because there were many other factors involved, such as pathologists operating hours on surgical pathology, number of public holidays, etc. Additionally, the number of extra specimens needed for further analysis was also a factor. Such cases can occur when there was incomplete patient's record for diagnosis, or extra tissue sectioning, or when a special staining procedure was required because of some types of disease complications. Those diseases, which cannot be diagnosed with regular staining procedure, were, for example, lymphoma, breast cancer, sarcoma, where specific staining technique is required for treatment. Furthermore, lecturing is one of the job responsibilities of professors in Khon Kaen University, as well as developing learning and teaching quality in classrooms and laboratories. Thus, being the Constraint, pathologists were unable to spend as much time on surgical pathology as they are supposed to. In the long run, promoting pathology training to medical residents would increase the number of pathologists or service providers.

Comments

Working overtime should be considered as an option to increase productivity and prepare for a large number of specimens in the future. Quality assurance should also be investigated after the application of the theory in the surgical pathology process. If the Theory of Constraints was applied to the whole hospital system, idling and waiting time should be reduced which would be beneficial to patients or service receivers.

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