Recommendations to Reduce Patient's Total Time Spent in Surgery Department Using Six Sigma

G. Suman and D. R. Prajapati

***Abstract*—This paper provides the recommendations in order to reduce the total time spent by the patients in surgery department. Six Sigma's DMAIC (Define-Measure-Analyze-Improve-Control) procedure is being applied in northern Indian rural hospital. Detailed data of the Inguinal Hernia's patients over a period of four months is considered for this study. The Average time spent and standard deviation is calculated to be 210.9 hours and 67.02 hours respectively. The individual cause and effect analysis are carried out for waiting time (WT) for surgery and length of stay (LOS) after surgery. After finding out the root causes, suggestions are provided to hospital administration after detailed discussion with doctors and staff members in order to reduce patient's total time spent.**

***Index Terms*— Length of Stay (LOS), Six Sigma, Surgery Department, Waiting time (WT)**

I. INTRODUCTION

There is huge demand of quality in healthcare but the certain amount of investment is required to meet the quality standards. From the World Bank data of 2014 on healthcare expenditure, it is found that total healthcare expenditure is approximately 10% of the world GDP. If we specifically talk about India, then Indian government spends only 1.5% of its GDP on healthcare which is among the lowest globally as compared to other countries.

Annual seminars organized by healthcare federation of India in 2017 reported that 16% of global share of maternal deaths, 27% of global new born deaths and 22% of global tuberculosis incidence still accounts by India. These states illustrates that there is great need of implementing any quality initiatives in healthcare sector in India.

The importance of quality initiatives in healthcare can be realized from severity factor. In case of other service sectors, the delays, errors can lead to loss of customer but does not cause any loss in terms of life whereas in case of healthcare, the delay of one or two minutes can make a difference in terms of life or death. So, as compared to other service sectors, the need of implementation of quality initiatives in healthcare is much more important. In order to reduce the waiting time, length of stay etc., Six Sigma proves to be very effective tool.

The present paper provides the suggestions to reduce the patient's total time spent in surgery department using Six Sigma. The patient with inguinal hernia is considered for the study. The total time is divided into two categories; i.e. waiting time (WT) for surgery and length of stay (LOS) after surgery. The detailed procedure starting from the patient's entry into the department to their discharge is carefully studied and finally cause and effect analysis is carried out.

Manuscript received March 10, 2019; revised April 02, 2019.

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II. LITERATURE REVIEW

Various researchers worked in this area and their contribution is summarized in this section.

Taner et al. [1] reduced the waiting time of patients before surgery using Six Sigma. A flow chart was prepared in order to get insight into the surgery process and cause and effect diagram was used to identify the possible root causes. The laboratory test reports and electrocardiogram availability were the main causes of waiting before surgery. Yu and Yang [2] applied the Lean and Six Sigma approaches to reduce the registration waiting time of the patient. Six Sigma DMAIC procedures was adopted to measure and analyze the existing process and to find the root causes of the problem. The Lean standard principles help to redesign the process by cutting down non-value added activities. Arena discrete event simulation software was used to support and verify the decisions. After the implementation of solutions, suggested in improve phase of DMAIC cycle, the average waiting time was reduced to 6.55 minutes from 42.3 minutes. Jackson and Woeste [3] applied Lean Six Sigma techniques to reduce the waiting time of patients in phlebotomy department. It was found that there was 50% reduction in waiting time led to increase productivity. Parks et al. [4] used Lean Six Sigma to reduce the delays in trauma care and they were successful in reducing trauma resuscitation units dwell time by one hour per patient.

Allen et al. [5] improved the hospital discharge process with Six Sigma DMAIC approach. Numerous tools were utilized in different phases of the Six Sigma like Pareto chart, cause and effect diagram, statistical process control etc. The authors focused on physician preparation and after considering these suggestions, the average discharge time was reduced to 2.8 hours from 3.3 hours. In addition to this improvement, there was additional benefit of reducing the missing chart data by 62%. Niemeijer et al. [6] reduced the length of stay for hip fracture using Six Sigma. The various variables effecting length of stay was discovered and new suggestions were incorporated in order to redesign the process pathway. As a result, there was reduction of length of stay by 4.2 days and average duration of surgery by 57 minutes.

Arafeh et al. [7] applied Six Sigma to decrease the patient waiting time in outpatient pharmacy, located in cancer treatment hospital. As a decision supporting tool, discrete

ISBN: 978-988-14048-6-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

event simulation model and design of experiments were employed. Various improvement opportunities are identified and implemented to reduce the waiting time. After the project, the waiting time of patients decreased by 50%. Lighter [8] utilized Six Sigma in Akron children's hospital and there was 90% decrease in waiting time for MRI in the radiology department. This increased the number of patients done with MRI and increased revenue. Berlanga and Husby [9] also made use of Six Sigma and Lean principles to shorten the emergency waiting time in Texas Medical Centre. There was significant improvement in terms of average time of emergency doctor to see patient, door to balloon time for heart attack patients etc.

Kutsal et al. [10] improved histopathology laboratory productivity using Six Sigma. The project caused the increase in Six Sigma score from 24% to 68% for all phases. Honda et al. [11] showed how the Lean and Six Sigma principles improve the hospital performance by taking 35 case studies. Al-Qatawneh et al. [12] provided a proposed framework to apply Six Sigma in the area of healthcare logistics. It also presented a case study implementing the proposed framework at a Jordanian hospital.

III. INGUINAL HERNIA

An Inguinal Hernia occurs when tissue, such as part of the intestine, protrudes through a weak spot in the abdominal muscles. The resulting bulge can be painful, especially when you cough, bend over or lift a heavy object. An Inguinal Hernia isn't necessarily dangerous. It doesn't improve on its own, however, and can lead to life threatening complications. The doctors normally recommend surgery to fix an inguinal hernia that's painful or enlarging. Inguinal hernia repair is a common surgical procedure.

Hernias can be repaired with either open or laparoscopic surgery. Open surgery requires a longer recovery process. The patient may be unable to move around normally for up to six weeks. Laparoscopic surgery has a much shorter recovery time, but the risk of your hernia reoccurring is higher.

IV. ABOUT THE HOSPITAL

The hospital under study is rural government Indian hospital situated in northern hill region. The hospital has bed capacity of 120. Along with well-equipped machines and equipment's, the hospital has positive attitude workers and staff. In hospital, the surgeons prefer open surgery for hernia.

V. METHODOLOGY

The total time spend in hospital by the inguinal hernia patients is divided into two parts; waiting time for surgery and length of stay after surgery. The detailed data is collected for 50 patients over a period of 4 months. The detailed procedure starting from the patient's entry into the emergency department to their discharge is carefully studied. The cause and effect analysis are individually done for waiting time for surgery and length of stay after surgery. In the end, after the detailed discussion with doctors and staff, recommendations are provided in order to reduce the patient's total time spent. The further subsections discuss the steps involved in the project.

A. Define

In this phase, specific problem is formulated and the goals of the project are outlined. The potential benefits to the customer are also realised, as well as the milestones needed to achieve the project goals. So it is very much clear that our problem is to reduce the patient's total time spent in surgery department. The project will result in increase in customer satisfaction and decrease in cost and time.

B. Measure

In the measure phase, the goal is to pinpoint the location or source of problems by building an understanding of existing process conditions and problems. The goal of this phase is to measure process performance metrics and determine performance requirements. The procedure to treat the Inguinal Hernia patients starting from their entry into the emergency department to their discharge is shown in Fig. 1.

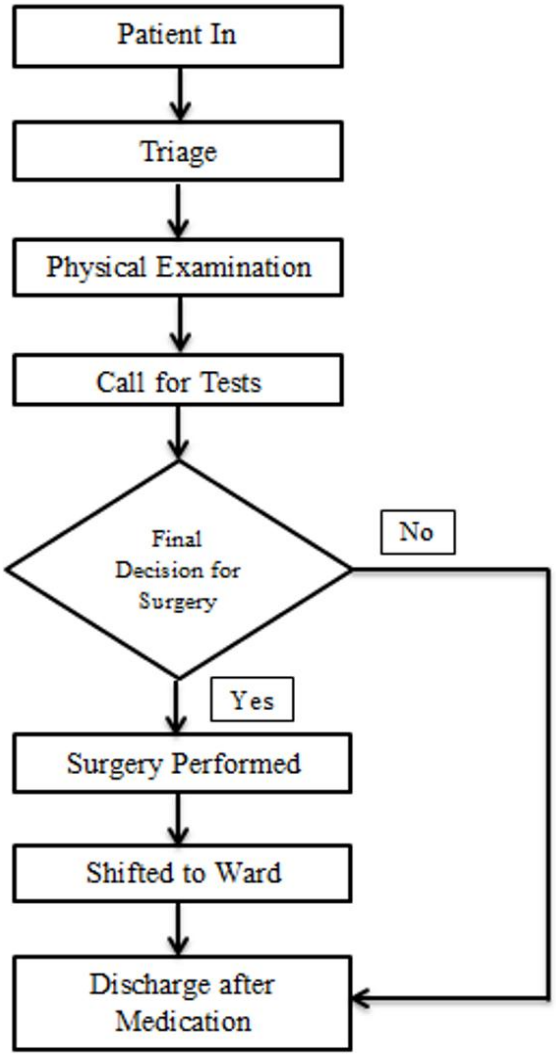

Fig. 1. Procedure for the Inguinal Hernia patient's starting from entry into emergency department to their discharge from surgical ward

Firstly the patient enters into the Emergency department. Then doctor assigns the degrees of urgency to illnesses to decide the order of treatment of a large number of patients

ISBN: 978-988-14048-6-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

through triage process. After that, physical examination is performed to confirm the hernia. The patient is examined in a standing position to increase intra-abdominal pressure, with the groin and scrotum fully exposed. If an obvious bulge is not detected, palpation is performed to confirm the presence of the hernia.

In the case of an ambiguous diagnosis, radiologic investigations like ultrasounds, Magnetic Resonance Imaging (MRI), Computed Tomography (CT) etc. may be used as an adjunct to history and physical examination. After getting results, the final decision is taken for surgery. If the decision for surgery is no, then the patient is discharged after medications. In other case, surgery is performed by the surgeons and after the surgery; patient is shifted to surgery ward. After sufficient recovery, finally the patient is discharged after medications.

The detailed data is collected for 50 patients over a period of 4 months. The average time spent in the department is calculated to be 210.9 hours and standard deviation to be 67.02 hours. The data for waiting time for surgery and length of stay after surgery is given in Appendix A.

C. *Analyze*

In this phase, analysis is done for current process timing. As the average time spent is calculated to be 210.9 hours (approximately 9 days) and standard deviation to be 67.02 hours (approximately 3 days), which needs to minimized and control. The Ishikawa diagram (Cause and effect analysis) is used to find out the root causes of the problem.

The cause and effect analysis is individually performed for waiting time for surgery and length of stay after surgery. Fig. 2 shows the cause and effect diagram for the waiting time for the surgery. The mean waiting time for surgery is calculated to be 28.91 hours with standard deviation of 30.69 hours (Appendix A). It is clear from the observed states that there is lot of variations in the data which needs to be control or minimized.

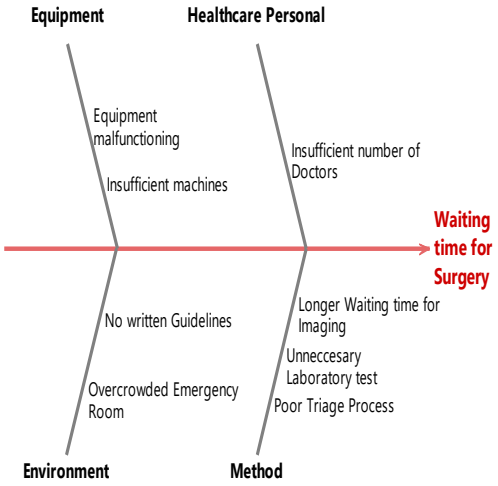

Fig. 2. Cause and effect analysis for waiting time for surgery

The detailed discussion is done with doctors and staff members in order to identify the possible causes; enlisted in cause and effect diagram. The causes such as 'Longer Waiting Time for Imaging' and 'Poor Triage Process' are validated by statistical analysis. The other potential causes such as 'Equipment Malfunctioning', 'No Written Guidelines', Overcrowded Emergency Room', 'Insufficient number of doctors' etc. could be validated by only through monitoring the process i.e. GEMBA.

In the GEMBA method, the process is observed for specific period of time in order to find out the availability of specific cause. So some of the causes are validated through GEMBA and rests are validated by statistical analyses. The results for statistical analysis of 'Longer Waiting Time for Imaging' and 'Poor Triage Process' is summarized in Table I. The process is monitored for specific period of time and results of GEMBA are summarized in Table II.

TABLE I
STATISTICAL ANALYSIS FOR WT FOR SURGERY

Causes	STATISTICAL ANALYSIS	Conclusion
Longer waiting time for imaging	It is calculated that averagely 2.5 hours are wasted in waiting for imaging	Root Cause
Poor triage Process	The averagely 1.95 hours are wasted in triage process	Root Cause

TABLE II
GEMBA OBSERVATIONS AND RESULTS FOR WAITING TIME FOR SURGERY

Causes	OBSERVATIONS	Conclusions
Equipment malfunctioning	Once in a month, there is malfunctioning of equipment.	Root Cause
Insufficient machines	There is only one ultrasound machine in the department, which leads to longer waiting time for patients	Root Cause
No written guidelines	There are no written guidelines, which leads to more and unnecessary patient's movement	Not a root cause
Unnecessary laboratory test	The inguinal hernia that is confirmed through physical examination, again confirm through imaging in most of the cases.	Not a root cause
Overcrowded emergency room	It is observed that 3 to 4 relatives come with one patient, make the emergency room overcrowded	Root Cause
Insufficient number of doctors	There is only 1 doctor per shift in Emergency room	Root Cause

Fig. 3 shows the cause and effect diagram for length of stay after surgery. The mean length of stay is calculated as 182.03 hours with standard deviation of 46.97 hours

ISBN: 978-988-14048-6-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

(Appendix A). Again the discussion is done with doctors and staff members in order to reach at the possible causes; enlisted in cause and effect diagram. The causes such as 'Longer Waiting Time for Reports' and 'Poor Discharge Implementation' are validated by statistical analysis. The other potential causes such as 'Availability of Senior Staff, 'Poor Storage system', Poor Maintenance', 'Doctor's Preferred Setting' etc. could be validated by GEMBA.

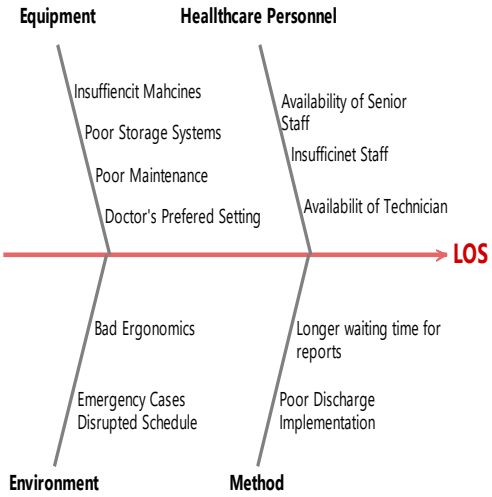

Fig. 3. Cause and effect analysis for length of stay after surgery

TABLE III
STATISTICAL ANALYSIS FOR LOS AFTER SURGERY

Causes	STATISTICAL ANALYSIS	Conclusion
Longer waiting time for reports	Averagely 6.7 hours are wasted in imaging reports.	Root Cause
Poor Discharge Implementation	The Averagely 4.75 hours are wasted in discharge process.	Root Cause

The results for statistical analysis of 'Longer Waiting Time for Reports' and 'Poor Discharge Implementation' is summarized in Table III. Similarly, the results of GEMBA for length of stay after surgery are summarized in Table IV.

D. Improve/Recommendations

On the basis of root causes identified in previous sections, the following recommendations are suggested to hospital administration:

1.) There is only one ultrasound machine in the department which is responsible for longer waiting time for the patients. The preference has to be given to the emergency patients over ward/regular patients but emergency patients also need to be in queue for their turn. So the first suggestion is to procure more ultrasound machine.
2.) Roughly once in a month, there is malfunctioning of equipment. So there should be proper calibration and service of the equipment. In fact, precaution is better than cure.
3.) In the observation, it is found that 3 to 4 relatives come with one patient; make the emergency room overcrowded. So the rule should be made to allow only one attendant with patient. This will reduce the emergency room crowd and allows the doctors to perform their duty well.

TABLE IV
GEMBA OBSERVATIONS AND RESULTS FOR WAITING TIME FOR SURGERY

Causes	OBSERVATIONS	Conclusions
Poor storage system	The storage and transport system of the files, samples etc. is not up to the mark.	Root Cause
Poor maintenance	There is not proper maintenance of the equipment.	Root Cause
Doctor's preferred setting	Technician provides machine to doctors with their preferred setting.	Not root cause
Insufficient Machines	There is one ultrasound machine but is sufficient for ward patients as there is no emergency.	Not root cause
Availability of Senior Staff	Most of time, Senior staff is not available in the ward.	Not root Cause
Availability of Technician	Technician is easily available in the department	Not root cause
Insufficient Staff	Staff is less in the ward which causes more load per head	Root Cause
Emergency Cases disrupted schedule	Emergency cases always disrupted schedule.	Root Cause
Bad Ergonomics	Improper ergonomics design of work place causing excessive stretching and bending during the work	Root Cause

4.) Number of doctors on duty in emergency room should be more than 2. One doctor is not sufficient to handle the patients; makes the room overcrowded.
5.) There should be ergonomically designed workplace (Like Chair, Table, and Computer etc.) in order to reduce excessive stretching and bending during the work.
6.) Nursing staff is very less in the department as well as in hospital. There is only one nurse per shift in the emergency department. Doctors also accept this fact that there is great need of more nursing staff in the hospital.
7.) There should be proper arrangement for storage and transportation of files, samples etc. so that they are easily traceable on time.
8.) Discharge implementation system should be quick. The patients have to wait averagely 4.75 hours after discharge by the doctors. So the documentation should be fast.

ISBN: 978-988-14048-6-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

VI. CONCLUSIONS

This paper is an attempt to reduce patients total time spent in surgery department using Six Sigma. The suggestions are provided after the detailed discussion with doctors and staff members. The study of detailed procedure starting from patient's entry into emergency department to their discharge helps to identify the root causes or gap within the systems. The provided suggestions will help the administration to reduce emergency crowd as well as patient's total time spent in the surgery department.

APPENDIX

The detailed data collected over a period of four month with waiting time for surgery, length of stay after surgery and total time in hours are shown in appendix A.

APPENDIX A
WAITING TIME FOR SURGERY AND LENGTH OF STAY AFTER SURGERY

Patient No.	WT for surgery (Hours)	LOS after Surgery (Hours)	Total time (Hours)
1	24.25	190.5	214.75
2	21.67	163.5	185.17
3	26.91	170	196.91
4	20.25	141.75	162
5	8.67	135.416	144.086
6	49.41	238.083	287.493
7	191.25	264.5	455.75
8	18.08	205.166	223.246
9	52.25	240	292.25
10	13.5	168.75	182.25
11	15.33	93.5	108.83
12	0.5	188.75	189.25
13	13.5	119.25	132.75
14	0.9167	193	193.9167
15	26.50	213.916	240.416
16	26.91	262.833	289.743
17	27.75	219	246.75
18	35.58	147.416	182.996
19	123.25	266	389.25
20	58.78	300.916	359.696
21	21.75	264.75	286.5
22	12	193	205
23	0.5	117.166	117.666
24	12	168	180
25	12	236.083	248.083
26	25.67	193.833	219.503
27	26	170.166	196.166
28	23	141.66	164.66
29	20.91	144.0833	164.993
30	21.75	143.25	165
31	23.41	187.666	211.076
32	12.58	191.25	203.83
33	23.58	141.5	165.08
34	19.58	158.5	178.08
35	44.08	168.75	212.83
36	38.25	159	197.25
37	26.25	192	218.25
38	24.08	119.5	143.58
39	44.58	215	259.58
40	11.41	167.25	178.66
41	27.5	119.25	146.75
42	4.83	212	216.83
43	4.58	144	148.58
44	25.75	217	242.75
45	21.25	116	137.25
46	54.08	161.166	215.246
47	53.16	212.25	265.41
48	13.5	142	155.5
49	16.5	236.5	253
50	25.91	146.75	172.66

ACKNOWLEDGMENT

The authors would like to acknowledge the hospital's administration as well as doctors and staff members who cooperate with us throughout the study.

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ISBN: 978-988-14048-6-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)