International Journal for Quality in Health Care, 2020, 32(8), 522–530
doi: 10.1093/intqhc/mzaa074
Advance Access Publication Date: 13 August 2020
Research Article

Research Article

Bundle interventions including nontechnical skills for surgeons can reduce operative time and improve patient safety

DAISUKE KOIKE[1,2,3,4], YUKIHIRO NOMURA[1], MOTOKI NAGAI[1], TAKASHI MATSUNAGA[2], and AYUKO YASUDA[3,4]

[1]Department of Surgery, Asahi General Hospital, 1326, I, Asahi, Chiba 289-2511, Japan, [2]Total Quality Management Center, Asahi General Hospital, 1326, I, Asahi, Chiba 289-2511, Japan, [3]Department of Quality and Safety in Healthcare, Fujita Health University, 1-98, Dengakugakubo, Kutsukake-cho, Toyoake, Aichi 470-1192, Japan , and [4]ASUISHI Project, Nagoya University Graduate School of Medicine, 65 Tsurumai-cho, Showa-ku, Nagoya 466-8550, Japan

Address reprint requests to: Ayuko Yasuda, 1-98, Dengakugakubo, Kutsukake-cho, Toyoake, Aichi 470-1192, Japan. Tel: +81-562-93-9716; Fax: +81-562-93-3711; E-mail: ayuko@fujita-hu.ac.jp

Editorial Decision 1 July 2020; Accepted 1 July 2020

Abstract

Objective: This study aimed to determine if introducing nontechnical skills to surgical trainees during surgical education can reduce the operation time and contribute to patient safety.
Design: Quality improvement initiatives using the KAIZEN as a problem-solving method.
Setting: Department of surgery in a referral and educational hospital.
Participants: Surgical team and quality management team.
Intervention: The KAIZEN was used as a problem-solving method between 2015 and 2018 to reduce the operation time. First, baseline measurement was performed to understand the current situations in our department. To achieve continuous improvement, periodical feedback of the current status was obtained from all staff. Bundles, including nontechnical skills, were established. Briefing and debriefing were performed by the surgical team.
Main Outcome Measures: Excessively long operation rates with a standard procedure.
Results: We included 1573 operations in this initiative. Excessively long operation rates were reduced in all types of surgeries, from 27.1% to 15.2% for herniorrhaphy ($P = 0.005$), 58.3–40.0% for gastrectomy ($P = 0.03$), 50.0–4.1% for total gastrectomy ($P = 0.12$), 65.6–45.0% for colectomy ($P = 0.004$), 67.8–43.2% for high anterior resection ($P = 0.02$) and 69.6–47.9% for low anterior resection ($P = 0.03$). The adherence to briefing and debriefing were improved, and majority of the surgeons favored the bundle elements.
Conclusions: The KAIZEN initiative was effective in clinical healthcare settings. In the event of scaling-up this initiative, the educational program for physicians should include project management strategies and leadership skills.

Key words: patient safety, surgery, nontechnical skills, quality improvement, implementation science

Introduction

Surgery is an important aspect of healthcare. Many life-threatening illnesses can be exclusively treated by surgical intervention including malignancies such as gastrointestinal cancer and infectious diseases such as acute peritonitis. However, potential surgery-related adverse events pose considerable risks for patients [1]. Half of all surgery-related adverse events are preventable; additional efforts are needed to improve the healthcare system and reduce the risks associated with surgery [2].

Surgery-related adverse events are generally considered to occur due to deficiencies in surgical knowledge, surgical techniques or patient management. However, improving these factors is not enough to reduce patient harm because surgery-related adverse events continuously occur [3–5]. Both tangible and intangible effects derived from a complex healthcare system are considered to exist.

Recently, the importance of nontechnical skills (NTSs) has become prominent [6]. NTSs are defined as behavioral aspects of performance that are derived from cognitive skills related to situational awareness and interpersonal skills, which are necessary for making decisions. Clinicians without adequate NTSs cause more adverse events [7–8]. The World Health Organization (WHO) has proposed a curriculum for patient safety that includes NTSs [9]. In the United States, the American College of Surgeons and the Association of Program Directors in Surgery provide the education curriculum for surgeons, including team-based skills [10]. Some studies have focused on improving communication in the operating room to improve patient safety by utilizing safety checklists during surgery [11]. However, NTSs or team-based training is rarely implemented in most countries, including Japan [12]. Therefore, effective initiative in the implementation of NTSs is necessary to improve patient outcomes.

Various studies have reported the existence of a surgical learning curve; this implies that several changes during the initial or early stages require surgeons to acquire proficiency with reasonable outcomes. This implies that, during the early phase, surgical outcomes are changing, the operation time is longer and the risk of morbidity and mortality is significantly higher [13–16]. These studies have assessed the influence of these factors on patient outcomes and focused on the experience of the surgeons, differences between minimally invasive and conventional surgery and different types of surgery. Since longer operations during learning curve are reportedly associated with a poor prognosis and negatively contribute to patient safety, it is important to establish educational programs to reduce operation time [17]. However, few studies have reported initiatives for reducing the risk of poor prognosis and complications for unexperienced surgeons. [18]

This study aimed to determine if the introduction of the NTSs involved in surgical procedures and surgical education would reduce the operation time, minimize complications and contribute to patient safety. This paper describes the process of our bundle implementation and its effects on the patient cohort.

Methods

Intended improvement

Quality improvement initiatives were performed following the decision to improve the surgical quality of our hospital. This initiative was based on the KAIZEN strategy and the TeamSTEPPS approach as a cultural change strategy [19]. Kaizen is a comprehensive approach employed in improving the quality of work in many fields and currently applied in healthcare. [20] Though the term 'Kaizen' is used in various contexts, KAIZEN in this paper was used as a problem-solving strategy involving several sequential steps such as understanding the current problem with data, setting clear targets, analyzing factors with context, developing countermeasures, implementing countermeasures and confirming effects. According to these strategies, initiative was implemented in sequence, as follows: we shared a sense of crisis, developed a goal for our department, developed the bundles (including NTS elements), evaluated the provision feedback with run-charts and re-developed the provision.

Setting

Our institution is an educational and referral hospital, and the WHO surgical checklist is standard for all operations [21]. In Japan, general surgical training lasts for 3 years after the completion of a 2-year fundamental postgraduate study; trainees must become board-certified surgeons by the Japan Surgical Society. The trainees perform approximately 150 surgeries per year and participate as an assistant in about 150–200 surgeries per year, experiencing in total approximately 300–350 surgeries per year. There are no established standard NTS programs associated with the education of surgeons in Japan.

Baseline period and understanding of the current situation

Baseline measurements were taken in April 2016 and were based on the data obtained between April 2015 and March 2016. During that period, 240 herniorrhaphies, 84 partial gastrectomies, 50 total gastrectomies, 93 colectomies, 59 high anterior resections and 46 low anterior resections were performed. The mean operative times were 73.6 min for herniorrhaphies, 322.7 min for partial gastrectomies, 367.1 min for total gastrectomies, 271.5 min for colectomies, 311.3 min for high anterior resections and 385.9 min for low anterior resections. Following the baseline measurements, we decided to improve the incidence rate of excessive operations and initiated interventions. We focused on the shared mental model based on the cultural change strategy, including the sense of impending crisis and our goal to improve patient outcomes in the surgical department. The mental models were shared throughout this initiative.

Intervention period 1 (PDSA1)

The measurement data were disclosed at our departmental conferences and a quality indicator conference in our hospital. Staff members in our department were not satisfied with their operative times. Therefore, we facilitated a better understanding of the necessity to improve initiatives and strategies. This improvement strategy was discussed with all staff. During this period, discussions were focused on technical skills. It was difficult to achieve immediate improvements in surgical skills as the required technical education program had already been implemented. To improve surgical quality, the operation time for each type of surgery was analyzed and shared with all staff in the department for 3 months.

During plan–do–study–act (PDSA1), some improvements were detected in the operation time. Although some staff appeared to conduct preoperative briefings and improved their operative times, the measurements were not standardized. The director of the department declared the following principles for our department to confirm the shared mental model: (i) surgery is for the patient; (ii) priorities: the patient is the first priority, surgical education is the second priority; and (iii) excessive surgery may have a negative impact on patients.

Table 1 The gap between assumed and target times for different types of surgery

	Assumption time[a] (min)	Target time[b] (min)	Measurement time[c] (min)	Gap between measurement and target time (min)
Herniorrhaphy	54	46	75	26
Partial gastrectomy	260	205	327	100
Total gastrectomy	310	265	385	111
Colectomy	220	170	284	111
High anterior resection	240	190	299	125
Low anterior resection	300	230	385	153

Values are presented as mean.
[a]Assumption time: average of answers to the questionnaire regarding estimated time.
[b]Target time: average of answers to the questionnaire regarding the target time.
[c]Measurement time: average of measurements during baseline period.

Consequently, presenting measurement data to the department had some positive effects on changing the performance of the trainees and instructors.

To visualize the gap between the actual performance and the target, the following questions were asked for every type of surgery: (i) 'How long are your own operation times?' (assumption time) and (ii) 'What are the standard operative times in our department?' (target time) (Table 1). There was a huge gap between the baseline measurement times and the assumption and target times for the surgeons. This gap was immediately shared with our staff to motivate them in improving their operative times.

Intervention period 2 (PDSA2)

A run-chart of operative time for each type of surgery was made between PDSA1 and PDSA2 (Supplementary Figures 1–6). The possible reasons for these trends were discussed using the charts. This initiative did not focus on the individual skills of each surgeon because prolonged surgeries were observed for all surgeons, including the instructors/experts. Instead, system thinking was used to improve patient safety and reduce operative time. The bundle developed in this initiative is summarized in Table 2. It includes situational awareness, decision-making, communication, teamwork and leadership, with shared mental models among the surgical team [22]. Operation time was classified into four grades, based on the type of surgery. Intraoperative management criteria and guidelines were established for instructors to enhance decision-making. The principles, standard operative times, and specific techniques were declared in conference and displayed on a bulletin board in our office.

Preoperative briefing and postoperative debriefing

The preoperative briefings and postoperative debriefings refer to dialogues exchanged by the surgical team before and after surgery for every patient. Both briefings occurred outside the operating room. Preoperative briefings included reviewing medical charts, discussing standard procedures and crucial points of the case, as well as formulating the details of the operative procedure, including support from additional staff and dividing the roles for the trainees and instructor. The purpose is to make surgeons aware of the surgical indications, operative procedures and their order, division of roles and any nonroutine steps. The surgical team could evaluate and share the knowledge of techniques and the level of achievement of the trainees and instructor. In this process, a shared mental model and enhanced teamwork were accomplished. Shared standard operative times and grading systems led to intraoperative situational awareness and decision-making for the resource management team. This is different from the briefing that is conducted using the WHO checklist in the operating room just before surgery [21]. Briefing and debriefing are required for every surgical case, even if the surgeries are routine.

Measurements

In this study, we included herniorrhaphy, partial or total gastrectomy, colectomy, high anterior resection and low anterior resection, which are considered standard procedures in general gastroenterological surgery. In addition, small variations in standard surgeries, such as gastrectomy with cholecystectomy, were included. Expansive operations, such as total pelvic excision, abdominoperineal resection for rectal cancer and total gastrectomy combined with pancreatectomy or thoracotomy, were excluded from this study. The data were collected from electronic medical records. Operation time was defined as the time from the first surgical incision until the skin was completely closed. The average operation time and the incidence of excessive operation times (to illustrate the effects of NTSs) were calculated monthly. Since no guidelines or standards for operative times have been published, the standard operative times were established by consensus after consideration of both the structure and environment of our hospital. Operative time was graded from A to D according to our criteria (Supplementary Table 1). Notably, excessive operation time was defined as grade D.

Data collection

The data were collected by the Total Quality Management Center in our hospital. Every 3 months, the data were reported back to our department. Morbidity, mortality and postoperative hospital stay were retrospectively analyzed as a balance measurement. After PDSA2, the adherence of the bundle was evaluated by a questionnaire, using a 5-point Likert scale.

Statistical analyses

All statistical analyses were performed using JMP® 14 (SAS Institute Inc., Cary, NC, USA). We used Student's t-test to compare continuous variables and the chi-squared test to compare categorized outcomes, as appropriate. The Cochran–Armitage test (P -value) was used to compare the three intervention stages. The Mann–Whitney U-test was used to compare the medians. Medians were reported with

Table 2 Perioperative bundles and operative time grades

Bundles
Preoperative bundle
The surgical team has a preoperative meeting (communication and team work)
The standard time is defined according to the type of surgery; a 'time out' announcement is made to the surgical team just before surgery (communication)
Preoperatively decide whether a trainee will participate during the procedure; consider the experience of both the instructor and trainee (decision-making and situational awareness)
Intraoperative bundle
Be aware of the operative times, as it reflects the situation (situational awareness)
In the cases of excessive operative time, the instructor must change the operator or ask for support from other surgeons (decision-making)
Postoperative bundle
Perform postoperative debriefing for the entire surgical team
Consider the causes and outcomes of excessive cases
Operative time grade
Grade A
Surgery was performed within a fair amount of time despite the trainee participation. These operative times confer minimal risk to patient safety
Grade B
Surgery was performed within the standard time, and the instructor conducted some of the procedures during surgery. These operative times confer minimal risk to the patient safety
Grade C
Surgery was performed within an excessive amount of time, and the instructor changed the operator to prevent further risks to patient safety
Grade D
Surgery was performed within a very excessive amount of time, and the instructor changed the operator and called for support from other surgeons. The surgical team created an occurrence report and discussed the incident

the interquartile range (25–75%), P values <0.05 were considered statistically significant and all P values were two-tailed.

Results

Patient characteristics

We included a total of 1573 operations and 42 surgeons (25 trainees and 17 instructors) in this initiative. Characteristics and outcomes of all surgeries are shown in Table 3. The frequencies of each type of surgery were comparable, although the frequency of herniorrhaphy gradually decreased from baseline to PDSA2. With regard to colectomy, the number of minimally invasive surgeries gradually increased. There were no between-group differences in patient sex and age.

Morbidity and mortality

Morbidity significantly improved in colectomy and low anterior resection (both $P = 0.03$), and mortality occurred in 10 cases. No significant differences in morbidity and mortality were detected among the operation groups. In the cases of low anterior resection, the morbidity rate gradually decreased. No significant differences in the re-operation rates were observed among the groups.

Operation times and excessively long operation rates

Compared to baseline measurements, improved operation times were observed for all surgery types (Table 3). Statistically significant differences were observed between baseline and PDSA2 for all types of surgery, except for total gastrectomy. The most significant difference between baseline and PDSA2 was observed in the cases of low anterior resection ($P = 0.02$); the operation time decreased by approximately 60 min. Excessively long operation (defined as grade D) rates were similarly reduced compared to baseline measurements, as follows: 27.1–15.2% for herniorrhaphy ($P = 0.005$), 58.3–40.0% for gastrectomy ($P = 0.03$), 50.0–34.1% for total gastrectomy ($P = 0.12$), 65.6–45.0% for colectomy ($P = 0.004$), 67.8–43.2% for high anterior resection ($P = 0.02$) and 69.6–47.9% for low anterior resection ($P = 0.03$) (Fig. 1). Improvements in grade D rates were statistically significant for all types of surgery, except for total gastrectomy.

Process measure and estimation of the surgeon

The adherence of the bundle was evaluated by questionnaires using a Likert score, as shown in Fig. 2. The adherence of briefing and debriefing improved in PDSA2 compared to PDSA1; however, only the improvement in briefing was significant ($P = 0.01$ and $P = 0.15$, respectively). Awareness of intraoperative situations and decision-making were evaluated only during PDSA2; situational awareness was well conducted, whereas decision-making was fairly well conducted. Inclusion of the bundles in this project was assessed for all surgeons. A majority (76.4%) of surgeons approved the effect of the bundle, including the decision-making element, and none opposed continuation of the initiative.

Discussion

During this study, a perioperative bundle was proposed to improve operative times in our department. The results demonstrated stepwise improvements in operative times after PDSA1 and PDSA2. The median operative time reduced by over 60 min in the low anterior resection group and by 50 min in the gastrectomy and high anterior resection groups. According to the Japanese Society of Gastroenterological Surgery, gastroenterological surgery is classified into three groups of difficulty [23]. Herniorrhaphy has a low difficulty;

Table 3 Patient characteristics based on surgery type

	Baseline period	PDSA1	PDSA2	*P* value
Herniorrhaphy				
Cases	240	218	184	
Male/female	217/23	194/24	165/19	0.88
Age (years)	68 (60–77)	69 (61–78)	70 (61–77)	0.66
Estimated blood loss (ml)	0 (0–0)	0 (0–0)	0 (0–0)	0.04*
Postoperative hospital stay (days)	1 (1–1)	1 (1–1)	1 (1–1)	0.97
Morbidity, *n*	7	3	3	0.32
Mortality, *n*	0	0	0	-
Operative time (min)	65 (52–82)	61 (47–80)	58 (47–73)	0.002**
Grade D, *n* (%)	65 (27.1%)	54 (24.8%)	28 (15.2%)	0.005**
Gastrectomy				
Cases	84	65	65	
Male/female	52/32	51/14	42/13	0.08
Age (years)	73 (65–80)	75 (67–79)	74 (66–82)	0.33
Minimally invasive surgery	30	29	28	0.12
Estimated blood loss (ml)	130 (21.25–320)	100 (12.5–310)	100 (27.5–270)	0.85
Postoperative hospital stay (days)	8 (6–13.75)	7 (6–14)	8 (6–13.75)	0.24
Morbidity, *n*	19	12	17	0.66
Mortality, *n*	1	0	1	0.19
Operative time (min)	313 (259.5–369.25)	319 (247.5–367)	278 (225.5–327.5)	0.004**
Grade D, *n* (%)	49 (58.3%)	37 (56.9%)	26 (40%)	0.03*
Total gastrectomy				
Cases	50	42	44	
Male/female	32/18	36/6	31/13	0.06
Age (years)	71 (65–76)	73.5 (63.25–78)	70 (65–74.3)	0.89
Minimally invasive surgery	8	6	3	0.67
Estimated blood loss (ml)	289 (172.5–536)	402.5 (237.75–573.75)	279 (130–560)	0.25
Postoperative hospital stay (days)	10 (8–15)	10 (8–13)	10 (8–18.5)	0.58
Morbidity, *n*	14	12	19	0.19
Mortality, *n*	0	0	0	-
Operative time (min)	355 (318.75–414.5)	346 (285.5–389.75)	316.5 (281–390.25)	0.11
Grade D, *n* (%)	25 (50%)	17 (40.5%)	15 (34.1%)	0.12
Colectomy				
Cases	93	104	111	
Male/female	58/35	66/38	61/50	0.38
Age (years)	71 (66–79)	72 (64.75–78)	74 (67–80)	0.49
Minimally invasive surgery	20	36	43	0.03*
Estimated blood loss (ml)	135 (30–277)	103.5 (12.5–279.25)	80 (10–220)	0.15
Postoperative hospital stay (days)	9 (7–18)	8 (7–10)	8 (6–12)	0.03*
Morbidity, *n*	17	14	9	0.03*
Mortality, *n*	1	1	2	0.64
Operative time (min)	265 (217–307.5)	238.5 (206.75–290)	230 (178–295)	0.007**
Grade D, *n* (%)	61 (65.6%)	51 (49%)	50 (45%)	0.004**
High anterior resection				
Cases	59	33	37	
Male/female	37/22	16/17	23/14	0.37
Age (years)	72 (65–78.8)	75 (69–80)	71 (64–77)	0.18
Minimally invasive surgery	20	14	14	0.72
Estimated blood loss (ml)	130 (10–472)	120 (2.5–332.5)	100 (10–345.5)	0.52
Postoperative hospital stay (days)	9 (7–17)	9 (7–26)	8 (7–17.3)	0.42
Morbidity, *n*	11	6	4	0.34
Mortality, *n*	1	0	1	0.77

Continued

Table 3 Continued

	Baseline period	PDSA1	PDSA2	*P* value
Operative time (min)	286 (232–355)	252 (221–301)	232 (200–287)	0.01*
Grade D, *n* (%)	40 (67.8%)	21 (63.6%)	16 (43.2%)	0.02*
Low anterior resection				
Cases	46	49	48	
Male/female	30/16	35/14	35/13	0.69
Age (years)	70 (63.25–76.75)	68 (61–72)	69 (62.25–76)	0.50
Minimally invasive surgery	16	14	13	0.44
Estimated blood loss (ml)	325 (28.8–617.8)	350 (35–1030)	191.5 (12.5–428)	0.12
Postoperative hospital stay (days)	21.5 (10.5–30.25)	18 (8–28.5)	13 (8–25)	0.08
Morbidity, *n*	19	11	10	0.03*
Mortality, *n*	1	0	1	0.98
Operative time (min)	361 (275–452.3)	332 (271.5–442)	296.5 (263–362.5)	0.02*
Grade D, *n* (%)	32 (69.6%)	29 (59.2%)	23 (47.9%)	0.03*

*$P < 0.05$.
**$P < 0.01$.
PDSA1, intervention period 1; PDSA2, intervention period 2.
Values are presented as cases or percentage or median and interquartile range.

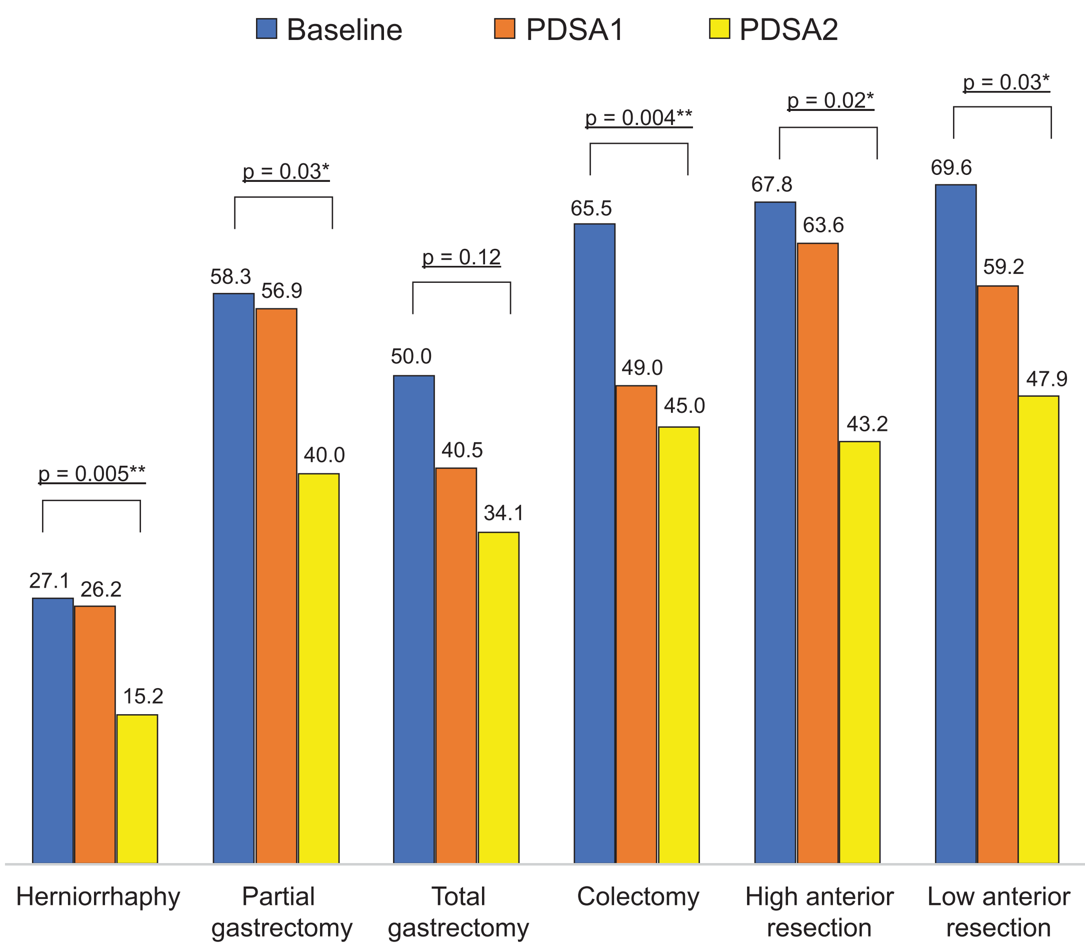

Figure 1 Rates of excessively long operations. The data are expressed as percentages (%). The Cochran–Armitage test was used to determine the trend. PDSA1, intervention period 1; PDSA2, intervention period 2; *$P < 0.05$; **$P < 0.01$.

gastrectomy, colectomy and high anterior resection have moderate difficulty; and total gastrectomy and low anterior resection have high difficulty. Notably, improvement was observed in all surgical types, regardless of the difficulty. These data suggested that the bundles and use of NTSs could be effective for improving patient outcomes and safety for any type of surgery, regardless of the difficulty.

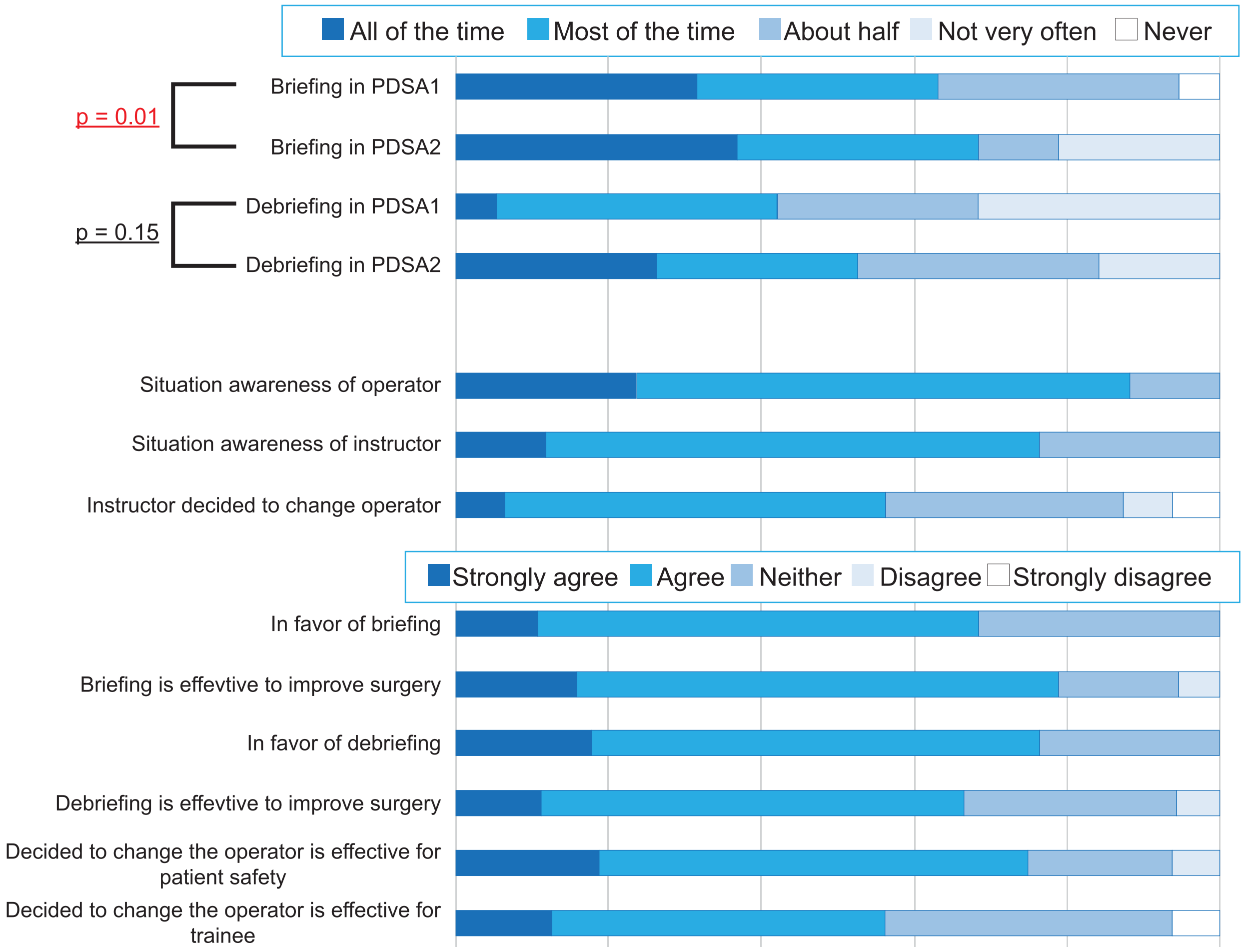

Figure 2 Process measurements and commitment of the surgeons regarding the implementation of the bundle. PDSA1, intervention period 1; PDSA2, intervention period 2.

Morbidities associated with colectomy and low anterior resection significantly reduced as the initiative continued. Although the power of the effect in this study was undoubtedly remarkable, the exact mechanisms and effect of NTSs underlying this improvement remain unclear because of the multifactorial effect of NTSs. Mundschenk et al. reported that trainees had no sufficient time to prepare for cases and individually learned to prepare for surgery, without the help of an instructor [24]. In the surgical hierarchy, trainees did not feel comfortable admitting the extent of preparation to their instructor; in some cases, they hesitated being taught by the instructor, even when inadequately prepared. In these situations, there is a threat of inadequate performance, which may put the patients at risk. Implementation of pre- and postoperative briefings could enhance communication and overcome the surgical hierarchy, because briefings generated changes in climate, behavior and systems in our surgical department.

Quality improvement initiatives in healthcare are generally challenging, even if their components are based on strong evidence; previous studies have reported ineffective or unsustainable initiatives [25–27]. There are several aspects to be transformed in implementing new manners, such as effectiveness, acceptability and penetration [28]. These results demonstrate clinical effectiveness. Because clinical professionals have the autonomy to improve their performance, visualization of clinical effectiveness reinforced surgeons/trainees continuing implemented practices. Therefore, periodic feedback of the data regarding clinical effectiveness to professionals can enhance the effectiveness, acceptability and penetration of the intervention. Acceptability is an important facet of this project. Most surgeons preferred brifing and debriefing practices, despite the additional workload, as shown in Fig. 2. These data similarly reflected the successful penetration of the surgeons and director of the surgical department. Although countermeasures to improve current situations were developed according to NTSs, it was developed by our own staff. This process is included in the KAIZEN method, and it could enhance the acceptability of the initiative. KAIZEN presented a potential to enhance acceptability and penetration, which could lead to success in all initiatives. The project leader of this study was trained by the ASUISHI program and collaborated with TOYOTA, which is a training program that utilizes the KAIZEN method for physicians and can lead to improvements in the quality and safety of healthcare in Japan [29]. When scaling-up quality improvement initiatives, educational programs that include KAIZEN as a problem-solving method and implementation science are helpful for physicians in facilitating the achievement of quality improvement.

This study has several limitations that should be addressed. Adherence of the bundles was decent in this study; however, the behavioral transformation of the surgeons while using the bundles was not directly observed. Although several perioperative NTS rating systems have been reported, these rating systems require observational staff and training to rate NTSs [30–32]. Because they were not suitable for clinical settings, we could not directly evaluate NTSs. More suitable and facilitated measurements of NTSs are necessary to clarify the potential effects of NTSs for improving surgical quality.

Feasibility and sustainability are similarly of concern in this study. Although the effectiveness of the bundle has been confirmed, the briefings in this study required a significant amount of time for both trainees and instructors. In many countries, physicians have an enormous amount of work, with the workload almost at its limit. [24] The time spent on briefings was not quantified as described earlier. Meanwhile, further study is needed to establish the feasibility. However, as this initiative required no special industrial or communication equipment, we believe it could equally be implemented in all countries and regions.

Conclusion

These results demonstrated that operative times decrease following quality improvement interventions using bundles with NTSs. Quality improvement initiative with an appropriate method is important for achieving patient safety and has the potential to initiate innovations, improve local healthcare problems and remodel the hierarchy and culture of healthcare systems.

Supplementary material

Supplementary material is available at *INTQHC Journal* online.

Acknowledgements

We thank all members of the Department of Surgery and Total Quality Management Center for their contributions. We particularly thank the staff of the ASUISHI project for education and encouragement. We pray from the bottom of our hearts that TM's soul rests in peace.

Funding

None.

Conflicts of Interest statement

The authors have no conflicts of interest to declare in regard to this work.

Ethical approval

Ethical approval was not required for this intervention.

Contributors

D.K., T.M., Y.N. and M.N. led this project and implemented the bundles. D.K. and T.M. collected and analyzed data. A.Y. was responsible for developing quality improvement methodology as the manager of the ASUISHI project. A.Y. critically revised the manuscript. D.K. drafted and submitted this manuscript. T.M. did not approve the final manuscript because he died in January 2019. All other authors approve of the manuscript in its current form.

References

1. Gawande A. Two hundred years of surgery. *N Engl J Med* 2012;366:1716–23.
2. Gawande AA, Thomas EJ, Zinner MJ *et al.* The incidence and nature of surgical adverse events in Colorado and Utah in 1992. *Surgery* 1999;126:66–75.
3. Christian CK, Gustafson ML, Roth EM *et al.* A prospective study of patient safety in the operating room. *Surgery* 2006;139:159–73.
4. Gawande AA, Zinner MJ, Studdert DM *et al.* Analysis of errors reported by surgeons at three teaching hospitals. *Surgery* 2003;133:614–21.
5. Vincent C, Moorthy K, Sarker SK *et al.* Systems approaches to surgical quality and safety: from concept to measurement. *Ann Surg* 2004;239:475–82.
6. Hull L, Athanasiou T, Russ S. Implementation science: a neglected opportunity to accelerate improvements in the safety and quality of surgical care. *Ann Surg* 2017;265:1104–12.
7. Lingard L, Espin S, Whyte S *et al.* Communication failures in the operating room: an observational classification of recurrent types and effects. *Qual Saf Health Care* 2004;13:330–4.
8. Hull L, Arora S, Aggarwal R *et al.* The impact of nontechnical skills on technical performance in surgery: a systematic review. *J Am Coll Surg* 2012;2144:214–30.
9. Ellis O. Putting safety on the curriculum. *BMJ* 2009;339:b3725.
10. Scott DJ, Dunnington GL. The new ACS/APDS skills curriculum: moving the learning curve out of the operating room. *J Gastrointest Surg* 2008;12:213–21.
11. Haynes AB, Weiser TG, Berry WR *et al.* Safe surgery saves lives study group. A surgical safety checklist to reduce morbidity and mortality in a global population. *N Engl J Med* 2009;360:491–9.
12. Tsuburaya A, Soma T, Yoshikawa T *et al.* Introduction of the non-technical skills for surgeons (NOTSS) system in a Japanese cancer center. *Surg Today* 2016;46:1451–5.
13. Waters JA, Chihara R, Moreno J *et al.* Laparoscopic colectomy: does the learning curve extend beyond colorectal surgery fellowship? *JSLS* 2010;14:325–31.
14. van Workum F, Stenstra MHBC, Berkelmans GHK *et al.* Learning curve and associated morbidity of minimally invasive esophagectomy: a retrospective multicenter study. *Ann Surg* 2019;269:88–94.
15. Carandina S, Montana L, Danan M *et al.* Laparoscopic sleeve gastrectomy learning curve: clinical and economical impact. *Obes Surg* 2019;29:143–8.
16. Kasotakis G, Lakha A, Sarkar B *et al.* Trainee participation is associated with adverse outcomes in emergency general surgery: an analysis of the National Surgical Quality Improvement Program database. *Ann Surg* 2014;260:483–90.
17. Shishido Y, Fujitani K, Yamamoto K *et al.* C-reactive protein on postoperative day 3 as a predictor of infectious complications following gastric cancer resection. *Gastric Cancer* 2016;19:293–301.
18. Mrdutt MM, Isbell CL, Regner JL *et al.* NSQIP-based quality improvement curriculum for surgical residents. *J Am Coll Surg* 2017;224:868–74.
19. Weld LR, Stringer MT, Ebertowski JS *et al.* TeamSTEPPS improves operating room efficiency and patient safety. *Am J Med Qual* 2016;31:408–14.
20. *KAIZEN Showcase of Engineering Patient Safety and Quality Culture: April 2018 Third Global Ministerial Summit on Patient Safety*. https://www.mhlw.go.jp/psgms2018/pdf/document/6_Document.pdf (25 May 2020, date last accessed).
21. *WHO Surgical Safety Checklist*. http://www.who.int/patientsafety/safesurgery/checklist/en/. (20 November 2019, date last accessed).
22. Yule S, Flin R, Paterson-Brown S *et al.* Development of a rating system for surgeons' non-technical skills. *Med Educ* 2006;40:1098–104.
23. *The Japanese Society of Gastroenterological Surgery*. https://www.jsgs.or.jp/modules/others/index.php?co. (20 November 2019, date last accessed)
24. Mundschenk MB, Odom EB, Ghosh TD *et al.* Are residents prepared for surgical cases? Implications in patient safety and education. *J Surg Educ* 2018;75:403–8.
25. Urbach DR, Govindarajan A, Saskin R *et al.* Introduction of surgical safety checklists in Ontario. *Canada N Engl J Med* 2014;370:1029–38.

26. Peden CJ, Stephens T, Martin G *et al.* Enhanced peri-operative care for high-risk patients (EPOCH) trial group. Effectiveness of a national quality improvement programme to improve survival after emergency abdominal surgery (EPOCH): a stepped-wedge cluster-randomised trial. *Lancet* 2019;393:2213–21.
27. Olomu AB, Stommel M, Holmes-Rovner MM *et al.* The American College of Cardiology's guidelines applied in practice. *J Qual Health Care* 2014;26:215–22.
28. Proctor E, Silmere H, Raghavan R *et al.* Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda. *Admin Pol Ment Health* 2011;38:65–76.
29. *ASUISHI Project*. http://www.iryoanzen.med.nagoya-u.ac.jp/asuishi/ (20 November 2019, date last accessed)
30. Yule S, Flin R, Maran N *et al.* Surgeons' non-technical skills in the operating room: reliability testing of the NOTSS behavior rating system. *World J Surg* 2008;32:548–56.
31. Undre S, Healey AN, Darzi A *et al.* Observational assessment of surgical teamwork: a feasibility study. *World J Surg* 2006;30:1774–83.
32. Passauer-Baierl S, Hull L, Miskovic D *et al.* Re-validating the observational teamwork assessment for surgery tool (OTAS-D): cultural adaptation, refinement, and psychometric evaluation. *World J Surg* 2014;38: 305–13.