Learning curve for laparoscopic reduction of intussusception in children who failed fluoroscopy-guided air enema

Y. H. Liu
Shanghai Children's Hospital, School of medicine, Shanghai Jiao Tong University

J. Sun (sunj@shchildren.com.cn)
Shanghai Children's Hospital, School of medicine, Shanghai Jiao Tong University

Z. B. Lv
Shanghai Children's Hospital, School of medicine, Shanghai Jiao Tong University

W. J. Xu
Shanghai Children's Hospital, School of medicine, Shanghai Jiao Tong University

J. B. Liu
Shanghai Children's Hospital, School of medicine, Shanghai Jiao Tong University

Q. F. Sheng
Shanghai Children's Hospital, School of medicine, Shanghai Jiao Tong University

Research Article

Keywords: intussusception, children, laparoscopy, learning curve

Posted Date: June 15th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1737498/v1

Abstract

Background Laparoscopic reduction in the treatment of intussusception in children who failed fluoroscopy-guided air enema has gained popularity recently. The question arises as to how many laparoscopic procedures are required before the technique is safely performed. This study aimed to evaluate and quantify the learning curve associated with laparoscopic reduction for intussusception at the authors' center.

Methods We performed a retrospective analysis of consecutive patients undergoing laparoscopic reduction by the same surgeon at our center between August 2014 and December 2020. Patient data including age, gender, BMI (body mass index), ASA (American Society of Anesthesiologists fitness grade), clinical manifestation, preoperative air enema attempts, operative time, anatomic type of intussusception, length of intussusception, No. of intussusception, recurrence of intussusception, pathologic lead point, concomitant procedure, complications, conversion, length of postoperative stay were analyzed over time to evaluate the learning curve.

Results A total of 34 patients received laparoscopic reduction of intussusception during the study period. The two groups were comparable, with their baseline demographics and clinical characteristics remained similar over time. Complications were experienced by 27% of the first 15 patients, which decreased to 0% during the next 19 patients ($p = 0.029$). The median operative time between the first 15 patients (45 min) and the next 19 patients (65 min) was not significantly different ($p = 0.822$). The median postoperative hospital stay was 4 days for the first 15 patients and 6 days for the next 19 patients ($p = 0.253$). The conversion rates were not significantly different between the first 15 patients (13%) and next 19 patients (16%) ($p = 1.0$).

Conclusions The complication rate was sharply decreased after 15 laparoscopic procedures. This indicates that the learning curve for laparoscopic reduction for intussusception of an experienced surgeon is approximately 15 cases.

Introduction

Intussusception is the most common cause of intestinal obstruction in children and infants[1]. Laparotomy has been the traditional approach for the treatment of intussusception not reducible by enema with air, saline, or barium. In recent years, laparoscopic approach was widely used in treatment of pediatric intussusception after been proved a safe and feasible approach with the benefits of minimally invasive surgery[2–7]. Yet there is no study on the learning curve for laparoscopic reduction of pediatric intussusception has been published. The purpose of this study is to retrospectively review our experience with laparoscopic approach of intussusception and to estimate the learning curve required for an experienced surgeon to become proficient with this procedure.

Materials And Methods

With the approval of the Ethics Committee of shanghai children's Hospital and patient written informed consent, a retrospective analysis was conducted on the first 34 consecutive patients（age 0–18 years） who underwent laparoscopic reduction of intussusception by a senior attending surgeon at this institution between August 2014 and December 2020. Patients who underwent laparoscopic reduction of intussusception in addition to other surgical procedures were excluded from the study.

Patient data regarding age, gender, body mass index (BMI), American Society of Anesthesiologists （ASA)fitness grade, clinical manifestation (duration of symptoms, body temperature, abdominal pain, nausea and vomiting, inconsolable crying, bloody stool, abdominal mass), recurrence of intussusception, pathologic lead point, preoperative air enema attempts, operative time, operative findings (anatomic types of intussusception, length of intussusception, No. of intussusception), complications, conversion, length of postoperative stay were analyzed over time to evaluate the learning curve.

The data were analyzed statistically using SPSS (IBM, version 25.0, Chicago, USA). All the categorical variables were described as frequencies and percentages while the continuous variables were expressed as means ± SDs (if the distribution was normal) or medians with interquartile ranges (if the distribution was skewed). For statistical analysis, comparison between groups was carried out using Fisher exact test for categorical variables and independent samples Student's t test or the Wilcoxon–Mann–Whitney test for continuous variables. Statistical significance was defined as a p value < 0.05.

Preoperative care

In patients who were admitted for suspected intussusception, diagnose was made by ultrasonography or diagnostic air enema when ultrasonographer is not available during off hours. All hemodynamically stable patients with no evidence of peritonitis received an attempt at pneumatic pressure enemas under fluoroscopy initially and appropriate fluid resuscitation if needed. A surgeon was present at time of radiographic reduction in case of complication. Up to three attempts of air enema were applied and for three minutes each. Air pressure was set at 80–120 mmHg. Delayed repeat enema was applicated only if 1) progressive movement of the intussusceptum on the prior reduction attempt; 2) patient stability; and 3) lack of peritonitis. The time intervals may range between minutes and hours.

A failed or incomplete reduction was followed by direct surgical intervention. The same scenario applies to cases with a pathologic lead point.

Laparoscopic approach

Laparoscopic treatment by the transumbilical route was attempted first. The surgery was performed by the same surgeon with advanced laparoscopic and open experience. The surgery was performed under general anesthesia. The patient is positioned supine and towards the end of the operating table and a nasogastric tube in place. The surgeon stood on the left side of the patient, with the first assistant driving the camera on the same side, and the scrub nurse standing across by the feet of the patient. The first 5-mm port was inserted through the umbilicus under direct vision for a 30-degree optical device and to

establish pneumoperitoneum. Carbon dioxide pneumoperitoneum was established to a pressure of 10mmHg, flow 1L per min. A quick inspection was carried out to identify the intussusception and its extension, and further assess the likelihood of success with laparoscopy according to the degree of bowel distention. Another two ports were placed under direct vision too. Their placement usually depends on the location of intussusceptum, which was identified by previous exploration and preoperative pneumatic enemas. Mainly, the incomplete reduction of the intussusception is localized at the ascending colon. Two ports were placed on the left side of the abdomen, one above and one below the level of the umbilicus or both below it. For better exposure, the operating table was tilted to left with a 30° head-up and foot-down (reverse Trendelenburg position). After locating the intussusception, reduction is achieved by gently squeeze the apex of the intussusception with two 5 mm atraumatic bowel graspers, just like milking gesture. Reduction at the ileocolic region is usually the most challenging part, which require more patience. Milking alone may not be effective so balanced traction and controlled steady pressure on the proximal intestine was helpful to a successful reduction (video 1). Following reduction the bowel was inspected for vitality, any injury to the bowel wall and to rule out any pathologic lead point. Appendectomy was considered in the setting of inflammation or ischemia.

Conversion to laparotomy

A standard right transverse supra-umbilical laparotomy was performed in instances wherein complete reduction cannot be achieved laparoscopically. The other scenarios for conversion to open procedure included evidence or strong clinical suspicion of bowel necrosis or perforation, pathological lead point, and limited working space with poor visualization due to bowel dilation.

For the purpose of our study, conversion was defined as instances where a switch from initial laparoscopic approach to a standard laparotomy, while longitudinal extension of umbilical incision to carry out bowel resection and anastomosis was deemed as laparoscopic procedure.

Postoperative care

In those minority of patients with bowel resection and anastomosis have been performed, antibiotic therapy was prescribed and parenteral feeding was continued until normal bowel peristalsis resumes.

In those majority of cases, intussusception successfully managed by laparoscopic reduction, antibiotics is not mandatory and oral feeding was resumed soon after recovering from anesthesia, started with clear fluids, and progressed to full oral feeding as tolerated. The patient was then discharged when they tolerated full feeding.

Results

During the study period, 34 patients were included in the study population and none was lost to follow-up. The complication rate was analyzed in groups of 5 patients to gain details regarding the learning curve. There was a dramatic decline in complication rate after 15 cases with the laparoscopic technique. The

results are shown in Fig 1. Patients were divided into two groups to analyze the difference between each period of the learning curve. The first group involved the first 15 patients, with the last 19 patients constituted in the second group.

Preoperative data

The study group consisted of 23 boys and 11 girls. There was no significant difference in gender (p = 0.151), age (p = 0.445), BMI (p = 0.099), ASA class (p = 0.113), duration of symptoms (p = 0.435), body temperature (p = 0.073), abdominal pain (p = 0.495), nausea and vomiting (p = 0.451), inconsolable crying (p = 1.0), bloody stool (p = 0.314), abdominal mass (p = 1.0), recurrence of intussusception (p = 0.856)or preoperative air enema attempts (p = 0.166). The two groups were comparable, with their baseline demographics and clinical characteristics remained similar over time (Table 1).

Perioperative data

The median operative times (incision to dressing) were not significantly different between the first group(45 min, range 35–140 min) and the second group (65 min, range 30–130 min, p = 0.822). The conversion rate was 13% (2/15) for the first group and 16% (3/19) for the second group. There were two cases in the first group (13%) was converted to open laparotomy for the limited working space due to extensive bowel dilation, while three conversions (16%) for strong clinical suspicion of pathological lead point in the second group (p = 1.0). There were no statistically significant differences between the two groups regarding length of intussusception (p = 0.297), anatomic types of intussusception (p = 0.154), No. of intussusception (p = 1.0). The overall complication rate associated with laparoscopic reduction of intussusception was rather low (12%). Complications included a postoperative port site hernia (in patient 15) requiring re-operative repair, and serosal tear in 3 patients requiring suture during the reduction (in patient 5,6,7). Complication rate was 27% (4/15) for the first group, whereas this rate decreased to 0% (0/19) during the second group (p = 0.029). A pathologic lead point was present in six patients (32%) for the second group, Meckel diverticulum, intestinal polyp and duplication cyst accounted for two cases respectively, compared with no patient in the first group (p = 0.024). The perioperative data were illustrated in detail in Table 2.

postoperative data

The median postoperative hospital stay was 4 days（range 3-7 days）for the first group and 6 days (range 4-7 days)for the second group (p = 0.253)(Table 2).

Discussion

Intussusception is the invagination of one part of the intestine (the intussusceptum) into another adjacent distal segment (the intussuscipiens)[8]. It is one of the most frequent causes of acute bowel obstruction in infants and toddlers[1]. As the first-line management for intussusception, non-surgical reduction, with barium, saline, or air, has high successful rate[5, 6]. According to the literature, the success

reduction rate varies in different institutions, from 80% to 95%[1]. During the study period, a total of 34 patients who underwent laparoscopic reduction of intussusception performed by a senior attending surgeon were recruited. In line with the literature, ileocolic intussusception is the most common anatomic type[1], which constituted the majority in our study, accounting for 76.5 %, followed by jejunojejunal and ileoileal (17.6%). The air enema reduction rate at our institution is 89% (278/312), which is identical to the literature. Surgical intervention is reserved for all patients, in which the intussusception was irreducible by enema techniques. Recently, laparoscopic reduction is demonstrated to be a safe and feasible approach and has been gradually recognized as the alternative to the open approach[3, 5, 9, 10]. However, all laparoscopic surgery would be confronted with conversion. The conversion rate from laparoscopic management to open procedure were extremely variable, ranging from 0% to 79%[6]. With a majority of the studies included the umbilical extension patients in the laparoscopic group[4], the overall conversion rate for the combined studies fell to 17%[2, 11]. The overall conversion rate of our study was even lower (14.7%) (5/34).

With the tremendous advancement of laparoscopic techniques in children in the recent years, its use in the management of intussusception become widely adopted. The question of how many procedures are needed to overcome the initial learning period becomes imperative. To date, there is still no reports of the learning curve for laparoscopic reduction of pediatric intussusception.

In our series, we reviewed our experience with laparoscopy in patients with radiologic irreducible intussusception and evaluated the learning curve associated with this procedure by comparing the complication rate between the first and the second groups. Obviously, the complication rate of the second group was far less than first group. Therefore, the first 15 patients might reflect the learning curve, with a dramatically declined in complications for the last 19 patients. This implied that the learning curve for laparoscopic reduction of intussusception in our research was 15 cases. Inconsistent with the complication rate, the operative time and postoperative length of hospital stay in the second group is obviously not shorter than the first group, in spite of the differences were not statistic significant. This contradiction might result from the imbalanced distribution of pathologic lead points in the two groups ($p = 0.024$). Of the 34 patients, 6 had a pathologic lead point, all in the second group and bowel resection and anastomosis were carried out by slightly extending the umbilical trocar incision in the midline and exteriorizing the lesion. No doubt these complex procedures added to the operative time. Likewise, children who underwent intestinal anastomosis had longer postoperative hospital stays than those who did not, as their time to tolerate full oral feeding is longer.

Although operative time may be easily measured and compared, it may not be the most proper endpoint of the learning curve[12]. In a laparoscopic procedure with formalized surgical approach, operative duration was most affected by the experience of the surgeon and can also vary with first assistant level, operating room nurses, anesthetists, and medical devices[13, 14]. In our present study, except for the first assistants were several different residents, the other factors were constant. If there is no standard surgical approach, operative time might be the most complicated parameter since it involves each step of

the procedure during the incision to dressing time. Additional procedures, such as appendectomy, lymph node biopsy, can prolong total operative time and may increase complication rate too. Since appendectomy does not seem to reduce the recurrence rate of intussusception, appendectomy was performed only if the appendix becomes inflamed or ischemia[2, 15]. Lymph node biopsy was performed when there was suspicion of lymphoma. Given the above, a standard laparoscopic approach to achieve reduction of pediatric intussusception was difficult to attain, as other researchers found out[4]. Hence, there was potential inherent bias as this was a heterogenous group of patients with lacking in standardized operative approach for children needing surgery for intussusception. Therefore, we did not take operative time as an endpoint to evaluate learning curve of laparoscopic reduction of intussusception.

However, our outcomes should be elucidated with caution, as there are several limitations in our study. One limitation relates to its retrospective design with lacking a standard protocol for data collection, which may impact data quality. Accordingly, we only involved the patients from the latest six years, as the patients' information are most complete and reliable. Fortunately, there is no patient loss to follow-up. Furthermore, retrospective studies are often limited by selection bias, whereby patients' baseline characteristics may affect their intervention option. With regards to our study, there was no significant difference in baseline characteristics between the two groups (age, gender, ASA class, BMI, clinical manifestation, preoperative air enema attempts, anatomic types of intussusception, length of intussusception, recurrence of intussusception, No. of intussusception, concomitant procedure). Thirdly, subject to the pediatric population and relatively high success rate of air enema, the demands for surgery have plummeted, which led to a limited sample size of our study and thus may generate type II error and affect the overall results. Additionally, there is potential recall bias with neglected minor complications, as we only documented the complications considered to be relevant and, especially, those involving certain forms of intervention. Lastly, we only analyzed the learning curve of a single surgeon in our center, lacking the comparison with other qualified surgeons or other institutions, which requires further investigation with these factors taken into account.

Conclusion

Through this study, it can be found that relied on the cooperation of the relative fixed team, the learning curve of surgeon with rich experience of laparoscopic technology is approximately 15 cases.

Declarations

Ethics approval: The study was approved by ethics committee of shanghai children's hospital.

consent to participate: Informed consent was obtained from all the parents of participants below 16 years of age.

Conflict of Interest: The authors declare that they have no conflict of interest.

Funding: None

Consent to publish: Not applicable

Statement on guidelines: The study was in accordance with relevant institutional guidelines.

Availability of Data and Materials: The data that support the findings of this study are available from the corresponding author on reasonable request, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available.

Authors' contributions: J. Sun: Conceptualization, Methodology, Writing- Reviewing and Editing. Y. H. Liu: Data curation, Writing- Original draft preparation, Software. W. J. Xu: Visualization, Investigation. Z. B. Lv: Supervision. J. B. Liu: Software. Q. F. Sheng: Validation

Acknowledgments: I would like to thank Dr. J. Sun for writing assistance, and professor Z. B. Lv for proof reading the article.

References

1. Arnold G. Coran NSA, Thomas M. Krummel, Jean-Martin Laberge, Robert C. Shamberger, Anthony A. Caldamone. Pediatric Surgery. Seventh ed. Philadelphia: Elsevier; 2012.
2. Lorraine I. Kelley-Quon LGA, Regan F. Williams, Adam B. Goldin, Shawn D. St. Peter, Alana L. Beres, Yue-Yung Hu, Elizabeth J. Renaud, Robert Ricca, Mark B. Slidell, Amy Taylor, Caitlin A. Smith, Doug Miniati, Juan E. Sola, Patricia Valusek, Loren Berman, Mehul V. Raval, Ankush Gosain, Matthew B. Dellinger, Stig Smme, Cynthia D. Downard, Jarod P. McAteer, Akemi Kawaguchi. Management of Intussusception in Children: A Systematic Review. J Pediatr Surg. 2021;56:587-96.
3. Cindy M. Sklar EC, and Ahmed Nasr. Laparoscopic versus open reduction of intussusception in children: a retrospective review and meta-analysis. J Laparoendosc Adv Surg Tech A. 2014;24(7):518-22.
4. Benedict LA, Ha D, Sujka J, Sobrino JA, Oyetunji TA, St Peter SD, et al. The laparoscopic versus open approach for reduction of intussusception in infants and children: An updated institutional experience. J Laparoendosc Adv Surg Tech A. 2018;28(11):1412-5.
5. Cheung ST, Lee KH, Yeung TH, Tse CY, Tam YH, Chan KW, et al. Minimally invasive approach in the management of childhood intussusception. ANZ J Surg. 2007;77(9):778-81.
6. Apelt N, Featherstone N, Giuliani S. Laparoscopic treatment of intussusception in children: a systematic review. J Pediatr Surg. 2013;48(8):1789-93.
7. Kao C, Tseng SH, Chen Y. Laparoscopic reduction of intussusception in children by a single surgeon in comparison with open surgery. Minim Invasive Ther Allied Technol. 2011;20(3):141-5.

8. Lewis Spitz AGC, daniel h teitelbaum, hock Lim tan, Agostino Pierro. Operative Pediatric Surgery. Seventh ed. Boca Raton, FL CRC Press; 2013.
9. Bailey KA, Wales PW, Gerstle JT. Laparoscopic versus open reduction of intussusception in children: a single-institution comparative experience. J Pediatr Surg. 2007;42(5):845-8.
10. Fraser JD, Aguayo P, Ho B, Sharp SW, Ostlie DJ, Holcomb GW, 3rd, et al. Laparoscopic management of intussusception in pediatric patients. J Laparoendosc Adv Surg Tech A. 2009;19(4):563-5.
11. Wei CH, Fu YW, Wang NL, Du YC, Sheu JC. Laparoscopy versus open surgery for idiopathic intussusception in children. Surg Endosc. 2015;29(3):668-72.
12. Kassite I, Bejan-Angoulvant T, Lardy H, Binet A. A systematic review of the learning curve in robotic surgery: range and heterogeneity. Surg Endosc. 2019;33(2):353-65.
13. Kuo LJ, Lin YK, Chang CC, Tai CJ, Chiou JF, Chang YJ. Clinical outcomes of robot-assisted intersphincteric resection for low rectal cancer: comparison with conventional laparoscopy and multifactorial analysis of the learning curve for robotic surgery. Int J Colorectal Dis. 2014;29(5):555-62.
14. Renaud M, Reibel N, Zarnegar R, Germain A, Quilliot D, Ayav A, et al. Multifactorial analysis of the learning curve for totally robotic Roux-en-Y gastric bypass for morbid obesity. Obes Surg. 2013;23(11):1753-60.
15. Bonnard A, Demarche M, Dimitriu C, Podevin G, Varlet F, Francois M, et al. Indications for laparoscopy in the management of intussusception: A multicenter retrospective study conducted by the French Study Group for Pediatric Laparoscopy (GECI). J Pediatr Surg. 2008;43(7):1249-53.

Tables

Table 1

patient characteristics comparisons between the two groups

	1st Group（n=15）	2ndGroup（n=19）	Statistic	P value
Gender （M/F）	8/7	15/4		0.151
Age in weeks	12（7.1,30）	20（8.4,45）	W=240.5	0.445
Duration of symptoms（h）	22（11,40）	16（12,26）	W=310	0.435
BMI（ kg/m2 ）	16.9（15.3,18.8）	15.6（14.7,18.0）	W=285	0.099
Body temperature(°C)	37.16±0.172	36.8±0.082	t=1.89	0.073
Abdominal pain	5/15	9/19		0.495
Nausea and vomiting	12/15	12/19		0.451
inconsolable crying	8/15	9/19		1.000
bloody stool	10/15	9/19		0.314
Abdominal mass	7/15	8/19		1.000
Recurrence of intussusception				0.856
once	12	13		
Two times	1	3		
More than two times	2	3		
Preoperative air enema attempts				0.166
0	3	0		
1	3	7		
2	8	9		
More than 2 times	1	3		
ASA class				0.113
I	0	4		
II	15	15		

Table 2

perioperative data comparisons between the two groups

	1st Group（n=15）	2nd Group（n=19）	Statistic	P value
Length of intussusception (cm)	10（7,15）	7（7,15）	W=303	0.297
Anatomic types of intussusception				0.154
Ileocolic	14	12		
Ileo-ileo-colic	0	1		
Cecocolic	0	1		
Jejunojejunal or ileoileal	1	5		
No. of intussusception				1.000
1	15	18		
2	0	1		
Concomitant procedure				
Appendectomy	5	8		0.728
Lymph node biopsy	0	2		0.492
Pathologic lead point	0/15	6/19		0.024*
Meckel diverticulum	0	2		
polyps	0	2		
Duplication cyst	0	2		
Operative time（min）	45（35,140）	65（30,130）	W=256	0.822
Postoperative hospital stay（days）	4（3,7）	6（4,7）	W=230	0.253
Conversion to laparotomy	2	3		1.000
Complications	4/15（27%）	0/19（0%）		0.029*
Port-site hernia	1	0		
serosal tear	3	0		

Figures

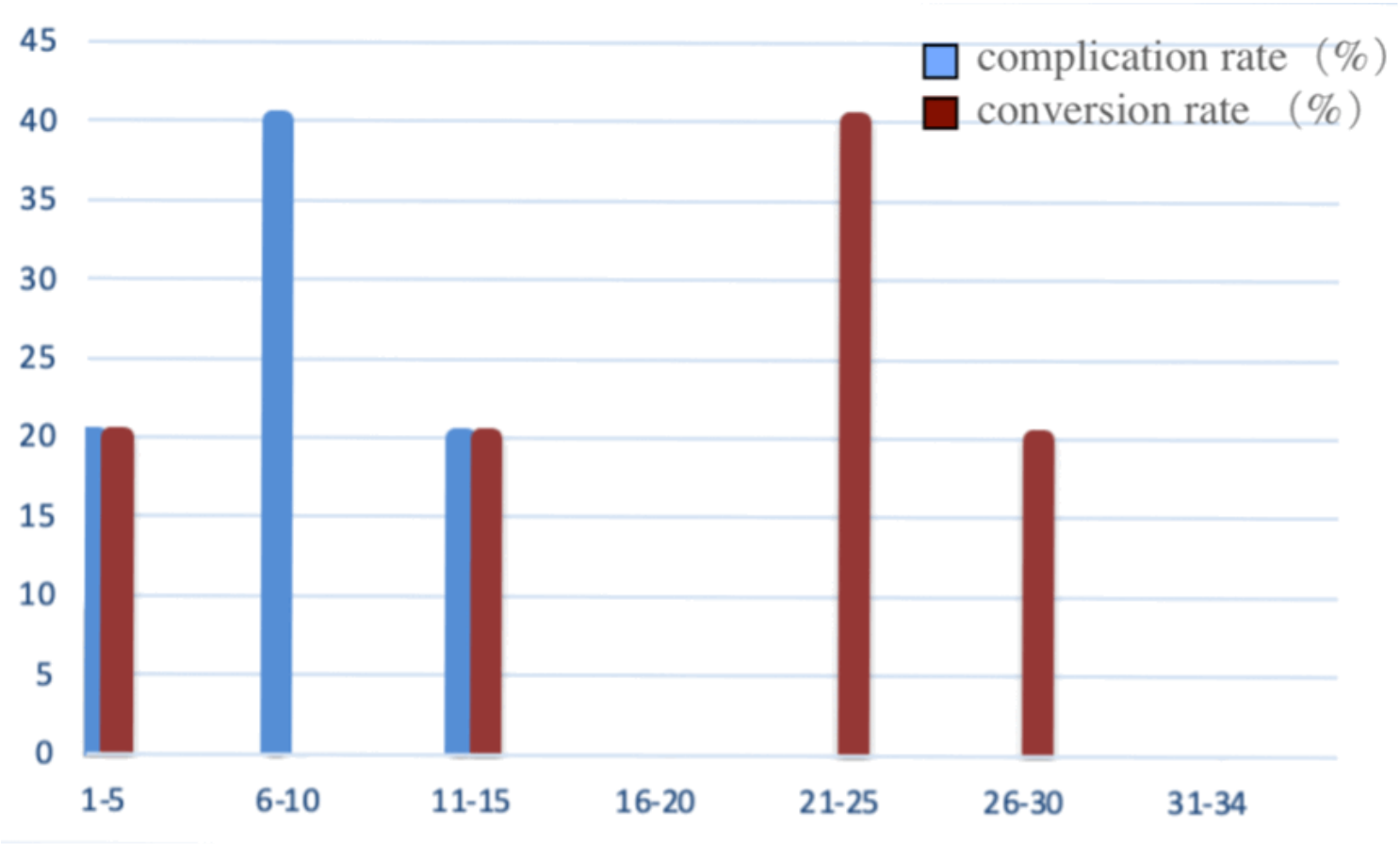

Figure 1

Analysis of the complication and conversion rates for patients grouped by 5. The vertical dimension shows the percentage of patients with the horizontal dimension shows the number of patients

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- video1still.jpg