ORIGINAL ARTICLE

Clinical and tomographic features associated with surgical management in adhesive small bowel obstruction patients

Características clínicas y tomográficas asociadas al manejo quirúrgico en pacientes con obstrucción intestinal de origen adherencial

Julián G. Toto-Morales, Ángel Martínez-Munive, and Fernando Quijano-Orvañanos*
Department of General Surgery, ABC Medical Center, Mexico City, Mexico

Abstract

Background: *The delay in surgical management of intestinal obstruction patients who did not respond to conservative management increases morbidity, mortality and days of hospital stay.* **Objective:** *This study aimed to describe the clinical and tomographic features associated with surgical management in adhesive small bowel obstruction patients.* **Method:** *We conducted a retrospective review of the electronic medical records during a 5-year period with the diagnosis of adhesive small bowel obstruction. We divided patients in two, those who responded to medical management and those who required surgery.* **Results:** *A total of 162 patients were included, with a mean age of 61.5 years. It was the first case of intestinal obstruction in 63% of the patients and 65.4% underwent surgery: 52.8% (n = 56) open surgery and 47.2% (n = 50) laparoscopic surgery. Multivariate analysis showed the following predictors of surgical treatment: abdominal rebound (odds ratio [OR]: 8.8; 95% confidence interval [95%CI]: 1.09-71.6), tomographic free fluid (OR: 4.62; 95%CI: 1.50-14.20) and transition zone (OR: 5.4; 95%CI: 1.59-18.80). The history of previous obstruction was a protective factor (OR: 0.33; 95%CI: 0.17-0.67).* **Conclusions:** *Abdominal rebound, free intrabdominal fluid and transition zone are related with the surgical management of adhesive small bowel obstruction.*

Keywords: *Small bowel obstruction. Surgery. Adhesions.*

Resumen

Antecedentes: *El retraso en el manejo quirúrgico de los pacientes con oclusión intestinal aumenta la morbimortalidad y los días de estancia intrahospitalaria.* **Objetivo:** *Describir las características clínicas y tomográficas de ingreso asociadas al manejo quirúrgico en pacientes con oclusión intestinal adherencial.* **Método:** *Revisamos los expedientes electrónicos de pacientes de los últimos 5 años con diagnóstico de oclusión intestinal adherencial y los dividimos según recibieran tratamiento conservador o tratamiento quirúrgico, y comparamos las variables.* **Resultados:** *Cumplieron los criterios de inclusión 162 pacientes, con una edad media de 61.5 años. El episodio capturado fue el primer episodio de oclusión intestinal en el 63% de los pacientes. Se realizó tratamiento quirúrgico al 65.4% de los pacientes (n = 106): 52.8% (n = 56) cirugía abierta y 47.2% (n = 50) cirugía laparoscópica. El análisis multivariado mostró los siguientes factores predictores de tratamiento quirúrgico:*

Correspondence:
*Julián G. Toto-Morales
Sur 136, 116 Las Américas, Del. Álvaro Obregón
C.P. 01120, Ciudad de México, México
E-mail: drjuliantoto@gmail.com

Date of reception: 01-07-2020
Date of acceptance: 09-12-2020
DOI: 10.24875/CIRUE.M23000293

Cir Cir (Eng). 2021;89(5):575-581
Contents available at PubMed
www.cirugiaycirujanos.com

presencia de rebote abdominal (odds ratio [OR]: 8.8; intervalo de confianza del 95% [IC95%]: 1.09-71.6), líquido libre (OR: 4.62; IC95%: 1.50-14.20) y zona de transición por tomografía (OR: 5.4; IC95%: 1.59-18.80). A history of prior bowel obstructions was a protection factor (OR: 0.33; IC95%: 0.17-0.67). **Conclusiones:** *El rebote abdominal, el líquido libre y la presencia de zona de transición por tomografía están asociados al manejo quirúrgico en los pacientes con oclusión intestinal adherencial.*

Palabras clave: *Obstrucción de intestino delgado. Cirugía. Adherencias.*

Introduction

Medical attention to patients with bowel obstruction is a very frequent task in surgical services as one of the leading causes of acute abdominal pain[1]. Approximately 7% of patients have bowel obstruction after their first abdominal surgery, and it is estimated that at least 25% will have it during the first year[2]. Although the majority will respond to conservative approaches, delay in surgery for those who eventually do not respond increases morbidity and mortality and the length of hospital stay[3,4]. A lower rate of mortality has been reported, as well as a lower rate of obstruction cases in patients treated surgically compared to those treated with a conservative approach[5,7], which is why we decided to investigate clinical and tomographic characteristics associated with surgical treatment in patients with bowel obstruction at the time of intake in order to characterize this subgroup of patients.

Method

This is a 5-year retrospective cohort study that included all patients over the age of 18 with an adhesive bowel obstruction diagnosis (CIE-9 54.5, 560.81, 560.9; CIE-10 56.5) and a complete electronic medical record, and they were divided in two groups according to conservative medical treatment and surgical treatment. The study excluded patients that had been operated 6 weeks before hospitalization with obstruction symptoms with neoplasic or hernia etiology, due to intestinal inflammatory disease or volvulus, as well as patients with incomplete records who had been transferred to hospitals before finding the outcome of the approach.

The primary objective was the surgical outcome, defined as those patients who underwent surgery at the time of admission or after a period of conservative medical approach. The clinical variable collected were age, gender, date of admission, date of surgery, number of abdominal surgeries prior to the bowel obstruction episode in question, the type of abdominal surgery, and the number of prior bowel obstruction episodes contained in the clinical history. All patients with a diagnosis of bowel obstruction without a history of prior abdominal surgery were included. The presence of comorbidity (diabetes *mellitus,* arterial hypertension, cardiopathy, and liver disease) was documented. The findings of the physical exam recorded at the time of admission were the presence of rebound effect, fever (> 38 °C), heart rate and presence of systemic inflammatory response syndrome, defined by the consensus of the American College of Chest Physicians y la Society of Critical Care Medicine[8] such as the presence of two or more of the following parameters > 38 °C or < 36 °C, heart rate > 90 heartbeats per minutes, tachypnea > 20 and leukocytes > 12.000 or < 4.000. The waste at the opening of the probe was defined as the waste obtained immediately after placement in the Emergency Room or during hospitalization. The laboratory variables included for the analysis were leukocytes, hematocrit, albumin, lactate, and ultrasensitive C-reactive protein.

Intake tomographies were reviewed and the presence of a transition area, the maximum diameter of the intestinal lumen prior to the transition area, the presence of free fluid in the peritoneal cavity, and sign of feces or bowel movement of the small intestine were analyzed. The images were reviewed by a radiology doctor.

We performed descriptive statistics with central tendency and dispersion measurements. The categorical variables are expressed as absolute and relative frequencies, and linear variable as a mean and standard deviation or median and intercuartile ranges according to the frequency distribution. Inferential statistics included the use of hypothesis tests to evaluate linear variables with Student t-test for related samples. The categorical variables were analyzed with the Chi square test. A sensitivity and specificity analysis was conducted in order to find the cut off point of the nasogastric tube opening waste that would predict the surgical outcome. The measurement of the strength of association used was the risk ratio with a confidence interval of 95% (CI95%) using as an outcome variable the need for surgical approach, and it was calculated through age and gender stratification with the Cochran-Mantel-Haenszel;

in addition, binary logistic regression models were built taking into account the same outcome and using admission clinical criteria as independent variables. A $p > 0.05$ was considered significant for two tails in all hypothesis tests. The statistics software package used was STATA SE 13.0.

Ethical aspects

The project complies with local and international regulations for research studies conducted in humans, according to the General Health Law and the Declaration of Helsinki. It is considered as risk-free research as data is obtained by reviewing clinical records.

Results

The records of 263 patients were reviewed, and 162 of them meet the inclusion criteria (Fig. 1) with a mean age of 61.5 years (± 15) and 52% of patients were females (n = 84). The following conditions were recorded as comorbidity: systemic arterial hypertension in 36% (n = 59), cardiopathy in 17% (n = 28) and diabetes *mellitus* in 6.8% (n = 11). In 7.4% of patients there was no abdominal surgery history in the first bowel obstruction episode (n = 12), 49.4% (n = 80) had a history of only one prior abdominal surgery, and 43.25% (n = 70) had a history of two or more abdominal surgical interventions (Fig. 2). The episode captured was the first bowel obstruction episode in 63% of patients (n = 102). 37% of patients (n = 60) reported at least one prior episode, and in 43% of them (n = 26/60) it was their third or more episode (Fig. 3). Among subjects with abdominal surgical history (n = 150), those with two or more abdominal surgeries were compared to those that only had one prior surgery, without observing the difference in the ratio of patients that underwent surgery and those who received conservative treatment (67.5 vs. 60%; p = 0.340). The frequency of the main types of abdominal surgeries prior to the bowel obstruction is shown in Table 1. Gynecological surgery was the most frequent in general terms, followed by appendectomy, cholecystectomy, and colon surgery. In the group with conservative treatment, a higher rate of bowel obstruction episodes was observed. The surgical group showed a higher frequency of rebound effect, longer hospital stays, and a higher rate of free fluid and transition area in tomography (Tables 2 and 3). Surgical treatment was provided to 65.4% of patients (n = 106) with the following approach: in 52.8%

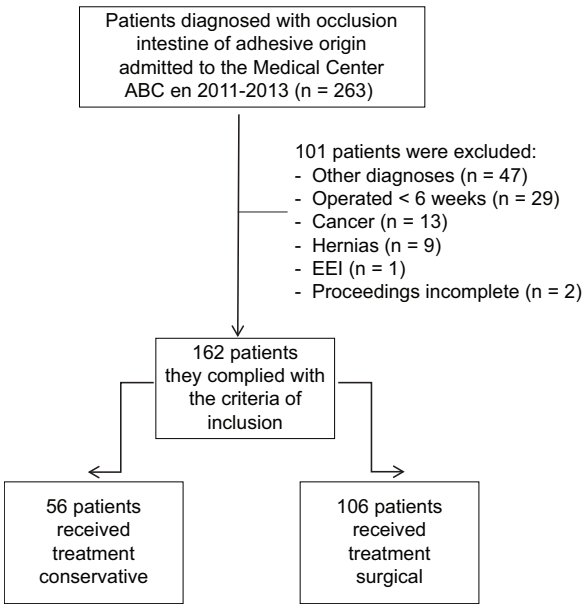

Figure 1. *Flow diagram of patient inclusion. IBD: Inflammatory Bowel Disease.*

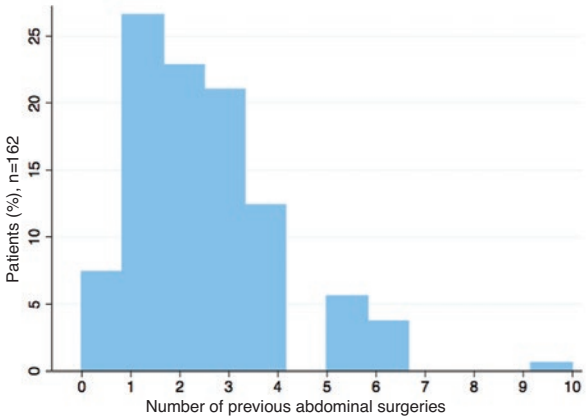

Figure 2. *Histogram with the percentage of patients according to the number of previous abdominal surgeries in subjects admitted with adherence bowel obstruction. The majority of patients had previous abdominal surgeries; the average was 1 episode.*

(n = 56) open surgery and in 47.2% (n = 50) laparoscopic surgery. 38% (n = 19) of them were converted to open surgery. When calculating the relative risk using as dependent variable the performance of a surgical procedure and classifying patients by age older or younger than 65, we found that having a history of bowel history was a protective factor to receive surgical treatment during hospitalization, and this protection only took place for patients over 65. The tomography risk variable were the transition area and the free fluid (Table 4).

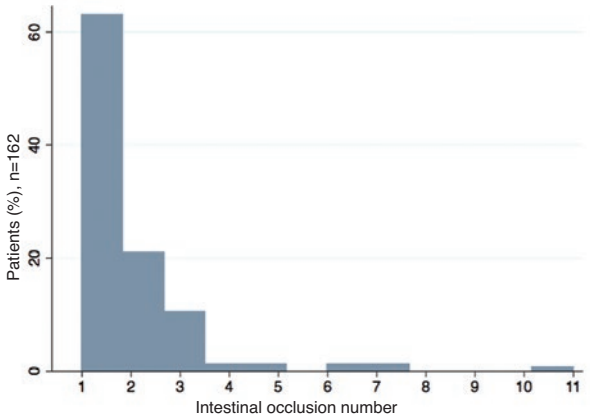

Figure 3. *Histogram with the percentage of patients according to the number of adherence abdominal obstruction at the time of admission. The higher rate of patients was experience their first obstruction episode (63%).*

Table 1. Main types of surgery in patients with bowel obstruction (n = 150)

Surgery	Frequency	Percentage*
Cholecystectomy	49	32.7
Colon surgery	43	28.7
Appendectomy	52	34.7
Gynecology (only women, n = 80)	80	79.3
Other	65	43.3

*Patients could have had more than one prior surgery, so the total percentage does not add to 100%.

Tabla 2. Comparison of general characteristics of patients with adherence bowel obstruction in the group with conservative treatment and in the group with surgical treatment

	Total (n = 162)	Conservative treatment (n = 56)	Surgical treatment (n = 106)	p
Medical history				
Female, n (%)	84 (51.9)	31 (55.4)	47 (44.3)	0.182
Age in years, mean (SD)	61.5 (15)	63.3 (14.1)	60.6 (16.2)	0.286
Diabetes *mellitus,* n (%)	11 (6.8)	5 (8.3)	6 (5.6)	0.432
Systemic arterial hypertension, n (%)	59 (36.4)	23 (41.1)	36 (33.9)	0.371
Cardiopathy, n (%)	28 (17.3)	13 (23.2)	15 (14.2)	0.147
Abdominal surgery prior to the first obstruction episode, n (%)	150 (92.6)	54 (96.4)	96 (90.6)	0.175
Two or more abdominal surgeries prior to the first obstruction episode, n (%)	70 (43.2)	28 (50)	42 (39.6)	0.205
Previous obstruction episodes, n (%)	60 (37)	30 (53.6)	30 (28.3)	0.002
Two or more previous obstruction episodes, n (%)	26 (16.1)	19 (33.4)	7 (6.6)	< 0.001
Clinical condition at the time of admission				
Systemic inflammatory response syndrome, n (%)	14 (8.8)	2 (3.6)	12 (11.5)	0.089
Fever, n (%)	2 (1.2)	1 (1.8)	1 (1.8)	0.644
Tachycardia, n (%)	12 (7.4)	3 (5.4)	9 (8.5)	0.469
Rebound, n (%)	16 (9.9)	1 (1.8)	15 (14.2)	0.012
Nasogastric probe opening waste (ml), mean (SD) (n = 129)	193 (340)	128 (35.8)	222 (39.8)	0.153
Average hospital stay (SD)	7.2 (6.3)	4.2 (3.2)	8.9 (6.1)	< 0.001

SD: standard deviation.

The multivariate analysis showed that the admission clinical factor that predicted that a patients would receive surgical treatment was the presence of abdominal rebound (odds ratio [OR]: 8.8; IC95%: 1.09-71.6), regardless of the presence of the systemic inflammatory response syndrome and the waste of the nasogastric probe opening when admitted. A history of prior bowel obstructions was a protection factor (OR: 0.33; IC95%: 0.17-0.67). The multivariate analysis showed that the tomography findings that predicted surgical treatment were the free fluid (OR: 4.62; IC95%: 1.50-14.20) and transition area (OR: 5.4; IC95%: 1.59-18.80).

Discussion

The demographical results of our study are consistent with other series, in which the mean age is around 60 years and with a clear female predominance[5,9,10], but, until now there is no evidence that being a woman is an independent risk factor for bowel obstruction[11]. This could be explained by demographical data: in our country, there are more women, and according to the figures provided by the Mexican Institute of Social Security, women are the subjects of 70% of all surgeries, particularly middle aged women[12]. Two thirds of patients had never shown prior bowel obstruction symptoms, and the vast majority had a history of at least one abdominal surgery, which is consistent with what has been reported by O'Leary, et al.[13] and with the knowledge that adherences (inevitably formed after surgery) are the direct cause of this condition[14].

Table 3. Laboratory and desk work in patients with adherence bowel obstruction in the conservative treatment group and surgical treatment group

	Total	Tratamiento conservador (n = 56)	Surgical treatment (n = 106)	p
Laboratory studies, mean (SD)				
Leukocytes (10^3/µl)	10.471 (3814) (n = 162)	9894 (3451) (n = 56)	10,776 (3974) (n = 56)	0.162
Hematocrit (%)	45.8 (6) (n = 162)	45 (6.1) (n = 162)	46 (5.9) (n = 162)	0.230
Albumin (mg/dl)	4.2 (0.57) (n = 124)	4.1 (0.53) (n = 44)	4.3 (0.57) (n = 88)	0.058
Lactic dehydrogenase (mg/dl)	185 (57) (n = 15)	172 (73) (n = 4)	190 (65) (n = 11)	0.603
Lactate (mmol/l)	1.96 (1.1) (n = 61)	1.71 (0.78) (n = 9)	2.0 (1.13) (n = 52)	0.463
Ultrasensitive C-reactive protein (mg/dl)	2.8 (5) (n = 82)	2.3 (2.9) (n = 25)	3.1 (5.6) (n = 57)	0.525
Tomography findings (n = 96)				
Free fluid	63.4 (61)	12 (42.3)	61 (63.5)	0.007
Transition area	97 (80.8)	23 (60.5)	70 (90.2)	< 0.001
Bowel movement	43(53.7)	15 (62.5)	28 (50)	0.304

Table 4. Relative risk of requiring surgery during hospitalization in patients with adherence bowel obstruction classified by age

	Total RR (CI 95%)	RR < 65 years (CI 95%)	RR ≥ 65 years (CI 95%)	p*
Clinical variables				
Type 2 diabetes *mellitus*	0.82 (0.47-1.43)	-	0.99 (0.57-1.71)	0.650
Systemic arterial hypertension	0.90 (0.70-1.45)	0.87 (0.58-1.31)	1.00 (0.68-1.47)	0.620
Cardiopathy	0.79 (0.55-1.13)	0.70 (0.31-1.58)	0.86 (0.56-1.34)	0.650
Prior abdominal surgery	0.77 (0.58-1.01)	0.67 (0.58-0.78)	(0.82-0.49-1.37)	0.159
Prior bowel obstruction	0.67 (0.51-0.89)	0.91 (0.67-1.24)	0.45 (0.27-0.74)	0.013
Abdominal rebound	1.5 (1.26-1.80)	1.5 (1.3-1.80)	1.36 (0.84-2.2)	0.592
Probe waste ≥ 250 ml (n = 129)	1.02 (0.81-1.27)	0.84 (0.61-1.16)	1.38 (0.93-2.05)	0.057
Systemic inflammatory response syndrome	1.36 (1.06-1.74)	1.26 (0.90-1.78)	1.48 (1.03-2.14)	0.532
Leukocytosis or leukocytopenia	1.01 (0.80-1.29)	0.89 (0.64-1.22)	1.19 (0.82-11.73)	0.234
Elevated lactate (n = 61)	0.98 (0.79-1.21)	1.14 (0.88-1.48)	0.80 (0.56-1.14)	0.111
Tomography variables (n = 96)				
Transition area	2.19 (1.24-3.89)	3.45 (1.26-9.37)	1.44 (0.75-2.75)	0.121
Free fluid	1.48 (1.07-2.05)	1.56 (0.89-2.27)	1.56 (0.99-2.47)	0.778
Bowel movement	0.86 (0.65-1.15)	0.75 (0.51-1.12)	1.03 (0.69-1.55)	0.255

*Obtained from the difference of ratios between both columns.
CI 95%: confidence interval of 95%; RR: risk rate.

In our series, only 7.4% of patients did not have a history of abdominal surgery, while the majority (49%) only had a prior laparotomy, similar to the results of some studies[15,16], which points to the possibility of obstructions that do not depend on the number of prior laparotomies. Between 30% and 40% of patients with bowel obstruction has had prior obstructions[15-17], which is consistent with the 37% of our series. In this case, the number of previous obstruction episodes (unlike the number of laparotomies) seems to influence the risk or recurrence, and the risk is higher, when the number of previous episodes is higher[6,15,18].

In the series by Komatsu, et al.[19], the surgical group had a higher average of prior laparotomies in the univariate analysis, and this result was not significant in the multivariate analysis. In our series there was no difference in the frequency of previous surgeries in both groups, and this situation goes against the idea that, the higher the number of previous surgeries, the lower the response to the conservative approach. In relation to the type of surgery, our finding of gynecological surgery as the most frequent type of surgery is consistent with what was reported by Barmparas, et al.[11], who reported, in a review of almost 450.000 abdominal surgeries, that the highest incidence of adherence obstructions was found in the group of patients with annex open surgery (23%), followed by ileorectal anastomosis with reservoir (19%), and abdominal hysterectomies (15%). However, for Williams, et al.[7], colorectal procedures are the most frequent, although their series with 321 patients corresponds to a colorectal surgery

department. On the other hand, we found no differences between the groups in terms of the types of previous surgeries, as reported by Meier et al.[6] in a retrospective analysis of 221 patients with obstruction. Two thirds of the patients required surgical treatment, basically reversing the roles of those series in which spontaneous resolution reaches 70-80%[5,20,21], although the literature shows series with similar surgical treatment rates[6,7].

The only clinical data at the time of admission that was associated with the surgical approach in our series was the presence of a rebound effect; however, when patients with strangulation at the time of admission are excluded, some studies do not report clinical or laboratory data associated with surgical approach[19-22], while others indicate the absence of gas channeling[17] or a high concentration of creatine phosphokinase in blood[16] as possible indicators of surgery. Zielinski, et al.[23] indicate that vomiting is a predictor of surgical treatment, but this is a non-exclusive series of patients with adherence obstruction. While there were no differences in our series in terms of the waste at the opening of the nasogastric probe, Komatsu, et al.[19] report that a waste of 500 ml after three days is a critical factor that predicts the surgical approach.

In relation to the tomographic findings, there are varied conclusions. As in our study, the presence of free fluid in other series[17,19,24] has been associated with the need for surgical treatment, especially in patients that have high density free fluid[25]. Hwang, et al.[26] report the transition area as a predictor of surgical treatment, as we did. Although it was not evaluated in our series, it is worth mentioning that many authors[16,17,24,26] are consistent with the fact that a high degree obstruction (absence of gas or liquid in the colon) is also an indicator for surgical treatment. Finally, while Zielinski et al.[23] reported in their univariate analysis that a history of obstructions is a factor associated with a successful conservative approach, our multivariate analysis states that it is a protection factor despite the fact that the prevalence of previous obstructions is similar to what has been reported in the literature.

The limitations of our study are due to its retrospective and single-center nature, which generates a potential selection bias; in addition, the cases are handled by different surgeon and internal medicine doctors, which impacts the approach and treatment of each patient despite existing international recommendations. However, we believes that the results can contribute to raise awareness of the need to perform a systematic approach that follows international guidelines, and cooperate in the decision making process when a patient has a bowel obstruction diagnosis.

Conclusions

The rebound effect and presence of the transition area and free fluid in the admission tomography of patients with adherence bowel obstruction were associated with the surgical approach. The admission laboratory tests and waste of nasograstric probe opening were not associated with the surgical approach. A history of bowel obstructions is associated with a lower need for surgical treatment.

Acknowledgments

The authors acknowledge Dr. Fernando Quijano Orvañanos for his valuable contribution to planning and creating this work.

Conflicts of interest

The authors state that they do not have any conflicts of interest.

Ethical disclosures

Protection of People and Animals. The authors state that no experiments have been conducted in humans or animals for this research.

Data Confidentiality. The authors state that the protocols of their work center regarding the publication of patient data have been followed.

Right to privacy and informed consent. The authors state that no patient information appears in this article.

References

1. Eskelinen M, Ikonen J, Lipponen P, Central S. Contributions of history-taking, physical examination, and computer assistance to diagnosis of acute small-bowel obstruction: a prospective study of 1333 patients with acute abdominal pain. Scand J Gastroenterol. 1994;29:715-21.
2. Parker MC, Ellis H, Moran BJ, Thompson JN, Wilson MS, Menzies D, et al. Postoperative adhesions: ten-year follow-up of 12, 584 patients undergoing lower abdominal surgery. Dis Colon Rectum. 2001;44:822-9.
3. Fevang BT, Fevang J, Stangeland L, Søreide O. Complications and death after surgical treatment of small bowel obstruction. Ann Surg. 2000;231:529-37.
4. Keenan JE, Turley RS, McCoy CC, Migaly J, Shapiro ML, Scarborough JE, et al. Trials of nonoperative management exceeding 3 days are associated with increased morbidity in patients undergoing surgery for uncomplicated adhesive small bowel obstruction. J Trauma Acute Care Surg. 2014;76:1367-72.
5. Foster NM, Mcgory ML, Zingmond DS, Ko CY. Small bowel obstruction: a population-based appraisal. J Am Coll Surg. 2006;203:170-6.
6. Meier RPH, Oulhaci W, Orci LA, Gutzwiller EM, Fre PM. Clinical outcome in acute small bowel obstruction after surgical or conservative management. World J Surg. 2014;38:3082-8.

7. Williams SB, Greenspon J, Young HA, Orkin BA. Small bowel obstruction: conservative vs. surgical management. Dis Colon Rectum. 2005;48:1140-6.
8. Bone RC, Balk RA, Cerra FB, Dellinger RP, Fein AM, Knaus WA, et al. American College of Chest Physicians/Society of Critical Care Medicine Consensus Conference: definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. Chest. 1992;101:1644-55.
9. De la Garza-Villaseñor L. Etiología de la oclusión intestinal. Rev Gastroenterol Mex. 2001;66:193-6.
10. Markogiannakis H, Messaris E, Dardamanis D, Pararas N, Tzertzemelis D, Giannopoulos P, et al. Acute mechanical bowel obstruction: clinical presentation, etiology, management and outcome. World J Gastroenterol. 2007;13:432-7.
11. Barmparas G, Branco BC, Schnüriger B, Lam L, Inaba K, Demetriades D. The incidence and risk factors of post-laparotomy adhesive small bowel obstruction. J Gastrointest Surg. 2010;14:1619-28.
12. Fernández-Cantón S. El IMSS en cifras. Las intervenciones quirúrgicas. Rev Med Inst Mex Seguro Soc. 2005;43:511-20.
13. O'Leary EA, Desale SY, Yi WS, Fujita KA, Hynes CF, Chandra SK, et al. Letting the sun set on small bowel obstruction: can a simple risk score tell us when nonoperative care is inappropriate ? Am Surg. 2014;80:572-9.
14. Menzies D, Ellis H. Intestinal obstruction from adhesions — how big is the problem? Ann R Coll Surg Engl. 1990;72:60-3.
15. Miller G, Boman J, Shrier I, Gordon PH. Natural history of patients with adhesive small bowel obstruction. Br J Surg. 2000;87:1240-7.
16. Tanaka S, Yamamoto T, Kubota D, Matsuyama M, Uenishi T, Kubo S, et al. Predictive factors for surgical indication in adhesive small bowel obstruction. Am J Surg. 2008;196:23-7.
17. Kulvatunyou N, Pandit V, Moutamn S, Inaba K, Chouliaras K, Demoya M, et al. A multi-institution prospective observational study of small bowel obstruction: clinical and computerized tomography predictors of which patients may require early surgery. J Trauma Acute Care Surg. 2015;79:393-8.
18. Fevang J, Lie SA, Svanes K, Viste A. Long-term prognosis after operation for adhesive small bowel obstruction. Ann Surg. 2004;240:193-201.
19. Komatsu I, Tokuda Y, Shimada G, Jacobs JL, Onodera H. Development of a simple model for predicting need for surgery in patients who initially undergo conservative management for adhesive small bowel obstruction. Am J Surg. 2010;200:215-23.
20. Menzies D, Parker M, Hoare R, Knight A. Small bowel obstruction due to postoperative adhesions: treatment patterns and associated costs in 110 hospital admissions. Ann R Coll Surg Engl. 2001;83:40.
21. Schraufnagel D, Rajaee S, Millham FH. How many sunsets? Timing of surgery in adhesive small bowel obstruction: a study of the nationwide inpatient sample. J Trauma Acute Care Surg. 2012;74:181-9.
22. Kubasiak J, Blears E, Veenstra B, Francescatti A, Myers J, Millikan KW, et al. Factors that predict failure of non-operative management of small bowel obstructions. Gastroenterology. 2014;146:S-1094.
23. Zielinski MD, Eiken PW, Bannon MP, Heller SF, Lohse CM, Huebner M, et al. Small bowel obstruction — who needs an operation ? A multivariate prediction model. World J Surg. 2010;34:910-9.
24. Chang W, Ko K, Lin C, Hsu H, Tsai S, Fan H, et al. Features on MDCT that predict surgery in patients with adhesive-related small bowel obstruction. PLoS One. 2014;9:1-8.
25. Matsushima K, Inaba K, Dollbaum R, Cheng V, Khan M, Herr K, et al. High-density free fluid on computed tomography: a predictor of surgical intervention in patients with adhesive small bowel obstruction. J Gastrointest Surg. 2016;20:1861-6.
26. Hwang J-Y, Lee JK, Lee JE, Baek SY. Value of multidetector CT in decision making regarding surgery in patients with small-bowel obstruction due to adhesion. Eur Radiol. 2009;19:2425-31.