A Diagnostic Score for Acute Small Bowel Obstruction

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Abstract. *Background/Aim:* The diagnosis of acute small bowel obstruction (ASBO) may be difficult and the decision to operate is based on clinical findings. So far, the diagnostic scores (DSs) for ASBO detection have been rarely evaluated. *Patients and Methods:* A cohort of 1,333 acute abdominal pain (AAP) patients with 54 ASBO patients, were included in the study. The most significant diagnostic findings (in multivariate logistic regression analysis) were used to construct DS formulas for ASBO diagnosis with location of pain at diagnosis (LP+) and without location of pain at diagnosis (LP-). Meta-analytical techniques were used to calculate the summary sensitivity (Se) and specificity (Sp) estimates for each data sets (history-taking, findings, and DS formulas). *Results:* In SROC analysis, the AUC values for i) clinical history-taking, ii) diagnostic findings and tests, iii) DS_{LP-} and iv) DS_{LP+} were as follows: i) $AUC=0.638$ ($95\%CI=0.600-0.676$); ii) $AUC=0.694$ ($95\%CI=0.630-0.724$), iii) $AUC=0.962$ ($95\%CI=0.940-0.986$), and for iv) $AUC=0.971$ ($95\%CI=0.952-0.988$). In roccomp analysis for the AUC values, the differences are significant as follows: between i) and ii) $p=0.312$; between i) and iii) $p<0.0001$; between i) and iv) $p<0.0001$; between ii) and iii) $p<0.0001$; between ii) and iv) $p<0.0001$; and between iii) and iv) $p=0.317$. *Conclusion:* The present study is the first to provide data that the DS could be used for clinical diagnosis of ASBO without radiological or laboratory analyses, to reach a high diagnostic accuracy in AAP patients.

Although the diagnosis of acute small bowel obstruction (ASBO) is sometimes difficult, the diagnosis and treatment of ASBO is necessary for intestinal preservation and avoiding the risk of complications. The clinical findings of ASBO include signs of peritoneal irritation and the acute abdominal pain (AAP) with distension, abnormal bowel sounds and a history of abdominal surgery, because adhesions are complications of abdominal surgery and the most frequent etiology of ASBO (1, 2). However, it is difficult to diagnose ASBO based on a single history-taking variable or a clinical finding. Physical examination of the patient is thus important for making the decision to operate or not. In practice, the decision of operation in patients with ASBO is based on doctor's clinical judgement. The lack of commonly accepted guidelines and diagnostic scoring (DS) for ASBO (1) encouraged us to evaluate the accuracy of the clinical diagnosis of ASBO among AAP patients. We designed the present study to assess the relative accuracy of i) a clinical history-taking, ii) clinical findings, as well as iii) the DS without location of pain at diagnosis (LP-) and iv) the DS with location of pain at diagnosis (LP+) in confirming ASBO among the patients with AAP.

Patients and Methods

A cohort of 1333 acute abdominal pain (AAP) patients with 54 ASBO patients was Included in the present. The clinical symptoms ($n=22$), signs ($n=14$) and laboratory tests ($n=3$) were recorded for each patient. The diagnosis of ASBO was confirmed by considering all clinical history-taking details, clinical findings and results of the laboratory tests and following the diagnostic criteria of ASBO as previously described (3-7) (Tables I and II).

Identifying the DS models. A multivariate logistic (stepwise) regression analysis (SPSS Statistics 26.0.0.1; IBM, Armonk, NY, USA) was used to disclose the variables with an independent predictive value. All the variables of clinical history and diagnostic findings presented in Tables I and II were included in the analysis as binary data e.g. ASBO=1 and other diagnosis of AAP=0. Using the coefficients of the regression model, a DS was built and its predictive value for ASBO was studied. The coefficient of the multivariate analysis shows the relative risk

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Table I. The clinical history of the acute small bowel obstruction (ASBO) patients versus other causes of abdominal pain.

Clinical history variable	Positive endpoint	Negative endpoint	TP	FN	FP	TN
1. Location of initial pain	Upper, center, lower abdomen, general	Other quadrants of the abdomen	47	7	761	518
2. Location of pain at diagnosis	Upper, center, lower abdomen, general	Other quadrants of abdomen	42	12	498	781
3. Duration of pain: Duration of pain at diagnosis	≤6 hours	>6 hours	26	28	435	844
4. Intensity of abdominal pain	Subjectively moderate or intolerable pain	Weak pain	43	11	830	449
5. Progression of pain from onset to diagnosis	Subjectively same or worse pain	Weaker pain than at the onset	42	12	846	433
6. Type of pain	Subjectively colicky or Intermittent pain	Steady pain	37	17	565	714
7. Aggravating factors	No aggravating factors	Movement, coughing, respiration, food or other	20	34	336	943
8. Relieving factors	Vomiting	Lying still, food, antacids or no relieving factors	10	44	88	1,091
9. Previous similar pain	Yes	No	21	32	426	840
10. Vertigo	Yes	No	4	50	36	1,239
11. Nausea	Yes	No	43	11	723	556
12. Vomiting	Yes	No	37	17	533	746
13. Appetite	No appetite	Normal appetite	50	4	927	352
14. Previous indigestion	Yes	No	18	36	261	1,016
15. Jaundice	No	Yes	53	1	1,247	30
16. Bowels	Constipation	Diarrhea, blood, mucus, white or normal stools	20	34	126	1,153
17. Micturition	Normal	Abnormal	52	2	1,195	84
18. Drugs for abdominal pain	Yes	No	4	50	50	1,228
19. Previous abdominal surgery	Yes	No	46	8	287	991
20. Previous abdominal diseases	Yes	No	19	35	214	1,063
21. Use of alcohol	No	Yes	1	53	1,212	66

(RR=en, n=β) of a patient with a given history-taking detail, clinical finding or test to have an ASBO.

The DS formula for ASBO without location of pain (LP-). DS: 0.83 × type of pain (positive endpoint=1, negative endpoint=0) + 2.45 × previous abdominal surgery (positive endpoint=1, negative endpoint=0) + 2.79 × distension (positive endpoint=1, negative endpoint=0) + 2.25 × bowel sounds (positive endpoint=1, negative endpoint=0) – 3.85 (Table III).

The DS formula for ASBO with location of pain (LP+). DS: 1.03 × location of pain at diagnosis (positive endpoint=1, negative endpoint=0) + 0.87 × type of pain (positive endpoint=1, negative endpoint=0) + 2.50 × previous abdominal surgery (positive endpoint=1, negative endpoint=0) + 2.57 × distension (positive endpoint=1, negative endpoint=0) + 2.20 × bowel sounds (positive endpoint=1, negative endpoint=0) – 7.22 (Table IV).

Statistical analysis. The other statistical analyses were performed using STATA/SE version 16.1 (StataCorp, College Station, TX, USA). Statistical tests presented were two-sided, and *p*-value <0.05 was considered statistically significant. Using 2×2 tables, we calculated sensitivity (Se) and specificity (Sp) with 95% confidence intervals (95%CI) for each clinical history-taking detail, finding or test, and using a meta-analytical technique (metaprop) separate forest plots for Se and Sp were created for each set of data, including each diagnostic variable (as equivalent to “study ID”). We calculated the summary estimates of Se and Sp, positive (LR+) and

negative likelihood ratio (LR-) and diagnostic odds ratio (DOR), using a random effect bivariate model and fitted the summary hierarchical receiving operating characteristic (HSROC) curves, including all diagnostic variables in the DS_{LP-} and DS_{LP+} models, using the ASBO endpoint.

Results

The clinical history-taking in ASBO. The overall Se of the clinical history-taking for detecting ASBO was 57% (95%CI=41-72%). Se was higher than 57% for 11 symptoms. The five best clinical history-taking variables (location of initial pain, appetite, jaundice, micturition, previous abdominal surgery) showed 85-98% Se in diagnosis of ASBO (Figure 1). The Sp of the history-taking for detecting ASBO was 57% (95%CI=42-72%) (Figure 2). Altogether, 12 symptoms showed Sp higher than 57%. The five best symptoms of ASBO (relieving factors, vertigo, previous indigestion, bowels, drugs for abdominal pain) showed 83-93% Sp (Figure 2).

The clinical findings and tests in ASBO. The overall Se of the diagnostic findings for ASBO was 75% (95%CI=62-86%) (Figure 3), and 10 findings had Se exceeding 75%. The five most accurate findings (colour, scar, mass, Murphy’s

Table II. The clinical signs and tests of the acute small bowel obstruction (ASBO) patients versus those with other causes of abdominal pain.

Clinical signs and investigations	Positive endpoint	Negative endpoint	TP	FN	FP	TN
1. Mood	Distressed or anxious	Normal	14	40	213	1,066
2. Colour	Normal	Jaundiced, pale, flushed or cyanosed	48	6	1,133	146
3. Abdominal movement	Poor/nil	Normal	10	44	83	1,195
4. Scar	Yes	No	46	8	300	978
5. Distension	Yes	No	36	18	57	1,218
6. Tenderness	Upper, center, lower abdomen, general	Other quadrants of the abdomen	37	17	342	937
7. Mass	No	Yes	54	0	1,245	34
8. Rebound	No	Yes	32	22	670	609
9. Guarding	Yes	No	34	20	673	606
10. Rigidity	No	Yes	45	9	993	285
11. Murphy's positive	No	Yes	53	1	1,155	123
12. Bowel sounds	Abnormal	Normal	41	13	148	1,131
13. Renal tenderness	No	Yes	44	10	928	351
14. Rectal digital tenderness	Normal	Abnormal	43	11	926	353
15. Body temperature	$\leq 37.1^{\circ}\text{C}$	$> 37.1^{\circ}\text{C}$	39	10	667	516
16. Leucocyte count (LC)	$> 10,000/\text{mm}^3$	$\leq 10,000/\text{mm}^3$	18	22	447	594
17. Urine	Normal	Haematuria or bacteriuria	42	0	1,054	72

TP: True positive; FN: false negative; FP: false positive; TN: true negative.

Table III. Diagnostic score for acute small bowel obstruction (ASBO) patients without 'location of pain at diagnosis' in the DS model (DS_{LP-}). The DS model is shown at six different cut-off levels of symptoms, signs and tests. Cut-off levels: DS I = -3.85, DS II = -3.56, DS III = -1.94, DS IV = -1.60, DS V = DS values between -3.85 and -1.60 excluded, n = 188 patients.

Diagnostic score (DS)	Positive endpoint	Negative endpoint	TP	FN	FP	TN
1. Logistic model DS_{LP-} I	ASBO	Other cause of abdominal pain	51	3	234	1,040
2. Logistic model DS_{LP-} II	ASBO	Other cause of abdominal pain	49	5	181	1,093
3. Logistic model DS_{LP-} III	ASBO	Other cause of abdominal pain	47	7	68	1,206
4. Logistic model DS_{LP-} IV	ASBO	Other cause of abdominal pain	43	11	54	1,220
5. Logistic model DS_{LP-} V	ASBO	Other cause of abdominal pain	43	3	54	1,040

TP: True positive; FN: false negative; FP: false positive; TN: true negative. Logistic regression analysis formula for DS: $0.83 \times \text{type of pain (positive endpoint=1, negative endpoint=0)} + 2.45 \times \text{previous abdominal surgery (positive endpoint=1, negative endpoint=0)} + 2.79 \times \text{distension (positive endpoint=1, negative endpoint=0)} + 2.25 \times \text{bowel sounds (positive endpoint=1, negative endpoint=0)} - 3.85$.

Table IV. Diagnostic score for acute small bowel obstruction (ASBO) patients with 'location of pain at diagnosis' in the DS model (DS_{LP+}). The DS model is shown at five different cut-off levels of symptoms, signs and tests. Cut-off levels: DS VI = -3.69, DS VII = -3.61, DS VIII = -2.75, DS IX = -2.45, DS X = DS values between -3.69 and -2.45 excluded, n = 130 patients.

Diagnostic score (DS)	Positive endpoint	Negative endpoint	TP	FN	FP	TN
1. Logistic model DS_{LP+} VII	ASBO	Other cause of abdominal pain	52	2	187	1,087
2. Logistic model DS_{LP+} VIII	ASBO	Other cause of abdominal pain	47	7	71	1,203
3. Logistic model DS_{LP+} IX	ASBO	Other cause of abdominal pain	50	4	136	1,138
4. Logistic model DS_{LP+} X	ASBO	Other cause of abdominal pain	47	7	62	1,212
5. Logistic model DS_{LP+} XI	ASBO	Other cause of abdominal pain	47	2	62	1,087

TP: True positive; FN: false negative; FP: false positive; TN: true negative. Logistic regression analysis formula for DS: $1.03 \times \text{location of pain at diagnosis (positive endpoint=1, negative endpoint=0)} + 0.87 \times \text{type of pain (positive endpoint=1, negative endpoint=0)} + 2.50 \times \text{previous abdominal surgery (positive endpoint=1, negative endpoint=0)} + 2.57 \times \text{distension (positive endpoint=1, negative endpoint=0)} + 2.20 \times \text{bowel sounds (positive endpoint=1, negative endpoint=0)} - 7.22$.

Figure 1. Sensitivities of the history-taking in acute small bowel obstruction (ASBO) (random-effects model). ES: Estimated sensitivity; CI: confidence interval.

positive, urine) showed 85-100% Se (Figure 3). The overall Sp of the findings was 47% (95%CI=30-65%) (Figure 4), while 8 findings showed Sp higher than 47%. The five most accurate findings (mood, abdominal movement, scar, distension, bowel sounds) showed 77-96% Sp (Figure 4).

The DS without location of pain (DS_{LP-}) in ASBO. The most important predictors of ASBO without LP at diagnosis were type of pain, previous abdominal surgery, distension and bowel sounds. The best diagnostic level for the DS_{LP-} formula (DS V; Se=93%, Sp=95%) was reached when the patients with DS_{LP-} values between -3.85 and -1.60 , were considered as “undefined” patients for whom follow-up is required (n=188) (Figure 5). The DS model was tested at five different cut-off levels to disclose the best diagnostic performance (Figure 5). The Se and Sp

of these five DS_{LP-} formulas were 89% (95%CI=84-94%) and 91% (95%CI=85-96%), respectively (Figures 5 and 6). Three of these formulas showed Se >89% and three formulas had Sp >91%. The best diagnostic DS_{LP-} formula in these ASBO patients (formula DS V, Figures 5 and 6) showed Se of 93% (95%CI=82-99%) and Sp of 95% (95%CI=94-96%).

The DS with location of pain (DS_{LP+}) in ASBO. The significant independent predictors (LP at diagnosis, type of pain, previous abdominal surgery, distension, bowel sounds) were used to build up the five different DS_{LP+} models. The Se and Sp of these five DS_{LP+} models were 92% (95%CI=88-96%) and 92% (95%CI=88-95%), respectively (Figures 7 and 8). Three formulas showed Se >92% and three formulas Sp over 92%. The DS_{LP+} (formula DS V,

Figure 2. Specificities of the history-taking in acute small bowel obstruction (ASBO) (random-effects model). ES: Estimated specificity; CI: confidence interval.

Figures 7 and 8) showed Se of 96% (95%CI=86-100%) and Sp of 95% (95%CI=93-96%) (Figures 7 and 8).

HSROC and comparison of the AUC values. STATA (metandiplot) was used to draw the HSROC curves to visualise the pooled overall diagnostic performance of the history-taking, findings and different DS formulas in detecting ASBO (Figures 9, 10, 11 and 12). In SROC analysis, the AUC values for i) clinical history-taking, ii) diagnostic findings and tests, iii) DS_{LP-} and iv) DS_{LP+} were as follows: i) AUC=0.638 (95%CI=0.600-0.676); ii) AUC=0.694 (95%CI=0.630-0.724), iii) AUC=0.962 (95%CI=0.940-0.986), and for iv) AUC=0.971 (95%CI=0.952-0.988). In roccomp analysis for the AUC values, the differences were significant as follows: between i) and ii) $p=0.312$; between i) and iii) $p<0.0001$; between i)

and iv) $p<0.0001$; between ii) and iii) $p<0.0001$; between ii) and iv) $p<0.0001$; and between iii) and iv) $p=0.317$.

Discussion

ASBO requires prompt recognition and early intervention. The decision to operate the patient with suspected ASBO is based on doctors' clinical judgement. The lack of commonly accepted guidelines and diagnostic scoring (DS) for ASBO (1) encouraged us to evaluate the accuracy of the clinical diagnosis of ASBO among AAP patients. The DS models published so far are based on clinicroadiological formulas which need computer tomography (CT) imaging in scoring. Jones *et al.* (8), in a retrospective study of ASBO patients, correlated CT scoring with the actual treatment and reported that dilated small bowel or free fluid in CT predicted ASBO

Figure 3. Sensitivities of the signs and tests in acute small bowel obstruction (ASBO) (random-effects model). ES: Estimated sensitivity; CI: confidence interval.

and their DS predicted the need for surgery in 75% of the patients. However, no ROC analysis with AUC values for the ASBO patients were reported in their study.

Schwenter *et al.* (9) applied a logistic regression model to construct a DS that would predict ASBO patients. Six variables correlated with ASBO and were given one point each: history of pain, guarding, C-reactive protein level ≥ 75 mg/l, leucocyte count (LC) $> 10,000/\text{mm}^3$, ascites volume ≥ 500 ml on CT and reduction of CT small bowel wall contrast enhancement. A DS ≥ 3 had Se of 67.7% and Sp 90.8%, with the AUC of 0.87 (95%CI=0.79-0.95). Zielinski *et al.* (10) reviewed retrospectively 100 ASBO patients who had undergone CT. The statistically significant predictors of ASBO in multivariate analysis were mesenteric edema, ascites and lacking of “small bowel feces sign” in CT imaging. Their clinicoradiological DS had Se of 96% and a positive predictive value (PPV) of 90% (OR=16.4,

95%CI=3.6-75.4) for ASBO. However, no ROC analysis was performed for the ASBO patients.

Huang *et al.* (11) analyzed retrospectively a cohort of ASBO patients and in multivariate analysis, Tax $\geq 38.0^\circ\text{C}$, sign of peritoneal irritation, LC $> 10,000/\text{mm}^3$, CT signs (thick-walled small bowel ≥ 3 mm), and ascites were significantly associated with ASBO, with AUC for their DS model reaching 0.935. Bouassida *et al.* (12) conducted a retrospective study including 124 ASBO patients. In logistic regression analysis, six independent predictive factors of ASBO were identified: age, pain duration, Tax, LC and CT signs of reduced wall enhancement and segmental mesenteric fluid. The AUC value of their clinicoradiological score was 0.92. In a retrospective study of 97 patients with ASBO, Ozawa *et al.* (13) used multivariate analysis, serum lactate levels, ascites, and peritoneal irritation sign in CT and generated a DS, which showed 92% Se and 75% Sp for

Figure 4. Specificities of the clinical signs and tests in acute small bowel obstruction (ASBO) (random-effects model). ES: Estimated specificity; CI: confidence interval.

ASBO diagnosis. Unfortunately, no ROC analysis was available.

Our interest was to compare the performance of the clinical history-taking variables, clinical findings and laboratory tests to discriminate ASBO patients from those of AA and NSAP patients reported in our previous study (4), to determine whether common clinical variables differ in ASBO and AA/NSAP patients. The overall Se of the history-taking in ASBO (57%, 95%CI=41-72%), significantly lower than that detecting AA among NSAP patients (75%, 95%CI=60-87%). In contrast, the Sp of the clinical history-taking in diagnosis of ASBO (57%, 95%CI=42-72%) was significantly higher than that in AA/NSAP patients (35%, 95%CI=23-49%). Instead, the Se of the clinical findings and laboratory tests in ASBO (75%, 95%CI=62-86%) was lower than that among AA/NSAP patients (87%, 95%CI=81-92%). However, the Sp of the clinical findings and tests in

diagnosis of ASBO (47%, 95%CI=30-65%) was higher than that of the AA/NSAP patients (38%, 95%CI=19-59%).

When the performance of the DS models was compared between ASBO and AA/NSAP patients, the trend was similar. The Se of the DS models in diagnosis of ASBO (92%, 95%CI=88-96%) was significantly higher than that in AA/NSAP patients (79%, 95%CI=72-85%). Although, Se and Sp usually behave reciprocally, it was a surprise to find that the Sp of the DS in ASBO patients (92%, 95%CI=88-95%) was similar to that in the AA/NSAP patients (95%, 95%CI=93-97%).

ASBO patients DS_{LP-} and DS_{LP+}. AUC values based on HSROC comparison test showed that the diagnostic performance of the clinical findings was slightly better than that of the clinical history-taking details only ($p=0.312$). However, as measured by the AUC values, the DS model was superior to both i) the clinical history-taking and ii) findings and tests.

Figure 5. Sensitivities of diagnostic scores without location of pain ($DS_{LP_}$) at five different cut-off levels (DS I-V). ES: Estimated sensitivity; CI: confidence interval.

Figure 6. Specificities of diagnostic scores without location of pain ($DS_{LP_}$) at five different cut-off levels (DS I-V). ES: Estimated specificity; CI: confidence interval.

Figure 7. Sensitivities of diagnostic scores with location of pain (DSL_{P+}) at five different cut-off levels (DS VI-X). ES: Estimated sensitivity; CI: confidence interval.

Figure 8. Specificities of diagnostic scores with location of pain (DSL_{P+}) at five different cut-off levels (DS IV-X). ES: Estimated specificity; CI: confidence interval.

Figure 9. Hierarchical summary receiver operating characteristic (HSROC) curve of the history-taking in acute small bowel obstruction (ASBO).

Figure 10. Hierarchical summary receiver operating characteristic (HSROC) curve of the clinical signs and tests in acute small bowel obstruction (ASBO).

Previous studies with a design similar to ours are scanty and only few retrospective studies with CT imaging have evaluated the applicability of the DS models in the ASBO population. Some previous studies have found a significant correlation between history of pain and ASBO (9, 12), but in the present study, the AUC value of the DS_{LP-} in ASBO patients (AUC=0.962, 95%CI=0.940-0.986) was almost identical with that in the DS_{LP+} patients (AUC=0.971, 95%CI=0.952-0.988).

Conclusion

As far as we know, there is paucity of DS models based on clinical findings and laboratory tests. Our results indicate that DS based on clinical findings could be an important part of the diagnostic algorithm, because the doctor's decision to operate patients with ASBO is based on clinical judgement (1). However, even with radiological and laboratory analyses (14-16), it may be difficult to reach a higher efficiency than the 97% AUC (Se/Sp balance) for the DS in ASBO. To date, the only DS study of patients with ASBO has not yet been closed and analyzed (17) and the present study is the first to provide data that the DS could be used for detection of

ASBO without radiological or laboratory analyses to reach a high diagnostic accuracy in AAP patients.

Conflicts of Interest

The Authors have no conflicts of interest or financial ties to disclose in relation to this study.

Authors' Contributions

All Authors contributed to the collection and analysis of data, drafting and revising the manuscript, read and approved the final manuscript.

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References

- 1 Ten Broek RPG, Krielen P, Di Saverio S, Coccolini F, Biffl WL, Ansaloni L, Velmahos GC, Sartelli M, Fraga GP, Kelly MD, Moore FA, Peitzman AB, Leppaniemi A, Moore EE, Jeekel J, Kluger Y,

Figure 11. Hierarchical summary receiver operating characteristic (HSROC) curve of the five (DS_{LP-}).

Figure 12. Hierarchical summary receiver operating characteristic (HSROC) curve of the five (DS_{LP+}).

- Sugrue M, Balogh ZJ, Bendinelli C, Civil I, Coimbra R, De Moya M, Ferrada P, Inaba K, Ivatury R, Latifi R, Kashuk JL, Kirkpatrick AW, Maier R, Rizoli S, Sakakushev B, Scalea T, Søreide K, Weber D, Wani I, Abu-Zidan FM, De'Angelis N, Piscioneri F, Galante JM, Catena F and van Goor H: Bologna guidelines for diagnosis and management of adhesive small bowel obstruction (ASBO): 2017 update of the evidence-based guidelines from the world society of emergency surgery ASBO working group. *World J Emerg Surg* 13: 24, 2018. PMID: 29946347. DOI: 10.1186/s13017-018-0185-2
- 2 Parker M, Ellis H, Moran B, Thompson J, Wilson M, Menzies D, McGuire A, Lower A, Hawthorn R, O'brien F, Buchan S and Crowe A: Postoperative adhesions. *Diseases of the Colon & Rectum* 44(6): 822-829, 2021. DOI: 10.1007/BF02234701
- 3 Eskelinen M and Lipponen P: Usefulness of history-taking in non-specific abdominal pain: a prospective study of 1333 patients with acute abdominal pain in Finland. *In Vivo* 26(2): 335-339, 2012. PMID: 22351680.
- 4 Meklin J, Eskelinen M, Syrjänen K and Eskelinen M: Leucocyte count does not improve the diagnostic performance of a Diagnostic Score (DS) in distinguishing Acute Appendicitis (AA) from Nonspecific Abdominal Pain (NSAP). *In Vivo* 34(6): 3327-3339, 2020. PMID: 33144440. DOI: 10.21873/invivo.12171
- 5 Meklin J, Eskelinen M, Syrjänen K and Eskelinen M: Gender-specific performance of a diagnostic score in Acute Appendicitis. *In Vivo* 34(6): 3687-3703, 2020. PMID: 33144486. DOI: 10.21873/invivo.12217
- 6 Eskelinen M, Meklin J, Syrjänen K and Eskelinen M: Performance of a diagnostic score in confirming Acute Cholecystitis among patients with acute abdominal pain. *Anticancer Res* 40(12): 6947-6956, 2020. PMID: 33288589. DOI: 10.21873/anticancer.14719
- 7 Eskelinen M, Meklin J, Syrjänen K and Eskelinen M: Pediatric acute appendicitis score in children with Acute Abdominal Pain (AAP). *Anticancer Res* 41(1): 297-306, 2021. PMID: 33419824. DOI: 10.21873/anticancer.14776
- 8 Jones K, Mangram AJ, Lebron RA, Nadalo L and Dunn E: Can a computed tomography scoring system predict the need for surgery in small-bowel obstruction? *Am J Surg* 194(6): 780-783; discussion 783-784, 2007. PMID: 18005771. DOI: 10.1016/j.amjsurg.2007.09.020
- 9 Schwenter F, Poletti PA, Platon A, Perneger T, Morel P and Gervaz P: Clinoradiological score for predicting the risk of strangulated small bowel obstruction. *Br J Surg* 97(7): 1119-1125, 2010. PMID: 20632281. DOI: 10.1002/bjs.7037
- 10 Zielinski MD, Eiken PW, Bannon MP, Heller SF, Lohse CM, Huebner M and Sarr MG: Small bowel obstruction-who needs an operation? A multivariate prediction model. *World J Surg* 34(5): 910-919, 2010. PMID: 20217412. DOI: 10.1007/s00268-010-0479-3

- 11 Huang X, Fang G, Lin J, Xu K, Shi H and Zhuang L: A prediction model for recognizing strangulated small bowel obstruction. *Gastroenterol Res Pract* 2018: 7164648, 2018. PMID: 29780412. DOI: 10.1155/2018/7164648
- 12 Bouassida M, Laamiri G, Zribi S, Slama H, Mroua B, Sassi S, Aboudi R, Mighri MM, Bouzeidi K and Touinsi H: Predicting intestinal ischaemia in patients with adhesive small bowel obstruction: A simple score. *World J Surg* 44(5): 1444-1449, 2020. PMID: 31925521. DOI: 10.1007/s00268-020-05377-6
- 13 Ozawa M, Ishibe A, Suwa Y, Nakagawa K, Momiyama M, Watanabe J, Yamagishi S, Kubota K and Endo I: A novel discriminant formula for the prompt diagnosis of strangulated bowel obstruction. *Surg Today*: 2021. PMID: 33420825. DOI: 10.1007/s00595-020-02213-1
- 14 Markogiannakis H, Memos N, Messaris E, Dardamanis D, Larentzakis A, Papanikolaou D, Zografos GC and Manouras A: Predictive value of procalcitonin for bowel ischemia and necrosis in bowel obstruction. *Surgery* 149(3): 394-403, 2011. PMID: 20869092. DOI: 10.1016/j.surg.2010.08.007
- 15 Netz U, Perry Z, Mizrahi S, Kirshtein B, Czeiger D, Sebbag G, Reshef A and Douvdevani A: Cell-free deoxyribonucleic acid as a prognostic marker of bowel ischemia in patients with small bowel obstruction. *Surgery* 162(5): 1063-1070, 2017. PMID: 28797546. DOI: 10.1016/j.surg.2017.06.015
- 16 Purdy M, Kokki M, Anttila M, Aspinen S, Juvonen P, Korhonen R, Selander T, Kokki H and Eskelinen M: Does the rectus sheath block analgesia reduce the inflammatory response biomarkers' IL-1ra, IL-6, IL-8, IL-10 and IL-1 β concentrations following surgery? A randomized clinical trial of patients with cancer and benign disease. *Anticancer Res* 36(6): 3005-3011, 2016. PMID: 27272818.
- 17 Clinicaltrials.gov. Diagnostic scoring for small bowel obstruction. Available at: <https://clinicaltrials.gov/ct2/show/NCT03461744> [Last accessed on February 12, 2021]

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