

Analysis of risk factors associated bowel resection in patients with incarcerated groin hernia

Peng Chen, MM^a, Wenming Yang, MM^a, Jianhao Zhang, MM^a, Cun Wang, MD^{a,b}, Yongyang Yu, MD^{a,b}, Yong Wang, MD^{a,b,*}, Lie Yang, MD^{a,b,c,*}, Zongguang Zhou, MD^{a,b}

Abstract

Background: Incarcerated groin hernia (IGH) is a common surgical emergency. However, there are few accurate and applicable predictors for differentiating patients with strangulated groin hernia from those with IGH. In this study, we aimed to identify the independent risk factors for bowel resection in patients with IGH.

Methods: We retrospectively collected 323 patients who underwent emergency hernia repair surgery for IGH between January 2010 and October 2019. The patients were categorized into those who received bowel resection and those who did not require bowel resection. The receiver-operating characteristic curve was used to identify the best cutoff values for continuous variables. Following this, univariate and multivariate analyses were performed to identify potential risk factors for bowel resection in these patients.

Results: Univariate analysis identified 6 variables that were significantly associated with bowel resection among patients with IGH. On multivariate analysis, neutrophil-to-lymphocyte ratio (NLR) (odds ratio [OR]=3.362, 95% confidence interval [CI] 1.705–6.628, $P=.000$) and bowel obstruction (OR=3.191, 95% CI 1.873–5.437, $P=0.000$) were identified as independent risk factors for bowel resection among patients with IGH.

Conclusion: In this study, an elevated NLR and those with bowel obstruction are associated with an increased risk of bowel resection among patients with IGH. Based on our findings, surgeons should prioritize prompt emergency surgical repair for patients who present with elevated NLR and bowel obstruction concurrent with IGH.

Abbreviations: BPH = benign prostatic hyperplasia, CI = confidence interval, COPD = chronic obstructive pulmonary disease, CRP = C-reactive protein, CT = computed tomography, IGH = incarcerated groin hernia, NLR = neutrophil-to-lymphocyte ratio, OR = odds ratio, ROC = receiver-operating characteristic, SD = standard deviation, SGH = strangulated groin hernia.

Keywords: bowel resection, incarcerated groin hernia, risk factors

1. Introduction

Groin hernia repair is a common procedure in general surgery; although groin hernias should be electively repaired to avoid complications, delayed diagnosis or repair of groin hernias often

result in incarceration, defined as irreducibility of the hernia.^[1] Incarcerated groin hernias (IGH) are one of the most frequent causes of acute abdomen, and approximately 5% to 15% patients with IGH require emergency surgery because of bowel incarceration or bowel strangulation, defined by objective

Editor: Zarko Babic.

PC, WY, and JZ contributed equally to this work, and above 3 authors should be considered first author.

This study was supported by National Natural Science Foundation of China (grant numbers 81472304); National Key Research and Development Program of China (grant numbers 2016YFC0906000 [2016YFC0906003]); Sichuan Science and Technology Program (grant numbers 2017JY0020); and 1.3.5 project for disciplines of excellence, West China Hospital, Sichuan University.

The authors report no conflicts of interest.

The datasets generated during and/or analyzed during the current study are publicly available.

^a Department of Gastrointestinal Surgery, West China Hospital, Sichuan University, ^b Institute of Digestive Surgery, State Key Laboratory of Biotherapy and Cancer Center, West China Hospital of Sichuan University, Chengdu, ^c Department of General Surgery, West China-Ziyang Hospital of Sichuan University/The First People's Hospital of Ziyang, Ziyang, Sichuan Province, China.

* Correspondence: Lie Yang, Department of Gastrointestinal Surgery, West China Hospital of Sichuan University, No. 37 Guoxue Lane, Chengdu 610041, China; Department of General Surgery, West China-Ziyang Hospital of Sichuan University/The First People's Hospital of Ziyang, No. 66 Rende West Road, Ziyang 641301, China (e-mail: lie_222@163.com); Yong Wang, Department of Gastrointestinal Surgery, West China Hospital of Sichuan University, No. 37 Guoxue Lane, Chengdu 610041, China (e-mail: wydoctor1974@allyun.com).

Copyright © 2020 the Author(s). Published by Wolters Kluwer Health, Inc.

This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial License 4.0 (CCBY-NC), where it is permissible to download, share, remix, transform, and buildup the work provided it is properly cited. The work cannot be used commercially without permission from the journal.

How to cite this article: Chen P, Yang W, Zhang J, Wang C, Yu Y, Wang Y, Yang L, Zhou Z. Analysis of risk factors associated bowel resection in patients with incarcerated groin hernia. *Medicine* 2020;99:23(e20629).

Received: 25 January 2020 / Received in final form: 24 April 2020 / Accepted: 8 May 2020

<http://dx.doi.org/10.1097/MD.00000000000020629>

evidence of ischemia.^[2,3] Moreover, due to the difficulties in clinical diagnosis, approximately 15% to 36% patients with IGH develop strangulated groin hernia (SGH),^[4–9] requiring prompt emergency hernioplasty with bowel resection, which has a higher morbidity (21%–39%) and mortality (4%–5%) rate than those reported for elective hernioplasty surgery.^[5,8,10,11] Early evaluation of bowel resection risk and timely surgery are critical for the outcomes in IGH patients.

Several risk factors have been reported for bowel resection, for example, female sex, older age, delayed hospitalization, severe comorbidities, femoral hernia, signs and symptoms of peritonitis, bowel obstruction, white blood cell count, neutrophilic leukocyte count, and poor American Society of Anesthesiologists physical status classification.^[6,8,11–13] However, previous research has determined these risk factors with limited sample size and without multivariate regression analysis, and thus may include confounding factors. This study aimed to conduct univariate and multivariate analyses to identify risk factors for bowel resection in 323 patients with IGH at a single institution, to provide further evidence for the clinical management of IGH.

2. Methods

2.1. Patient selection and data collection

We retrospectively collected data regarding 323 patients who underwent emergency hernia surgery for IGH from January 2010 to October 2019 at the West China Hospital in Chengdu, China. All data were collected from medical records of patient admitted during the study period and the following information was extracted: patient registration number, sex, age, duration of incarceration, admission season, hernia type, presence of bowel obstruction symptoms, history of previous abdominal surgery, presence of recurrent hernia, presence of concomitant disease, CT scan findings, bowel resection (yes/no) during hernioplasty, and preoperative hematological inflammatory markers such as white blood cell count, neutrophilic leukocyte count, neutrophil-to-lymphocyte ratio (NLR). This study was conducted in accordance with the standards of the Helsinki Declaration and current ethical guidelines and was approved by the Biomedical Ethics Committee of West China Hospital of Sichuan University. All patients were waived of informed consents due to the retrospective nature of this study.

The diagnosis of bowel obstruction was established when CT showed multiple stepwise air-fluid levels and dilated bowel loops. Duration of incarceration referred to the period from when the mass became irreducible to the time of hospitalization. Season of admission was defined as autumn and winter from September 23rd of 1 year to March 21st of the next year and spring and summer as the period from March 22nd to September 22nd. Concomitant diseases included chronic obstructive pulmonary disease, history of multiple pregnancies, liver cirrhosis or liver cancer, and benign prostatic hyperplasia.

2.2. Statistical analysis

ROC curve analysis was used to determine the best cutoff value for continuous variables such as age, duration of incarceration, preoperative white blood cell count, preoperative neutrophilic leukocyte count, and preoperative NLR. The optimal cutoff value was selected according to the maximum value of Youden index.^[14] The optimal cutoff value for NLR was calculated to be 6.5. The cutoff values for age, duration of incarceration, preoperative white blood cell count, and preoperative neutrophilic leukocyte count

were 57 years, 13 hours, 8.5×10^3 cells/mm³, and 7×10^3 /mm³, respectively.

χ^2 test was used to compare categorical variables. Continuous data are presented as mean \pm standard deviation (SD) or median (range). Comparisons of normal and non-normal continuous variables were conducted by Student *t* test and Mann–Whitney *U* test, respectively. Univariate and multivariate logistic regression analyses were used to explore risk factors for bowel resection in patients with IGH. All statistical analyses were performed using SPSS version 24.0 (SPSS, Inc, Chicago, IL). A 2-tailed *P* value of $<.05$ was considered significant.

3. Results

A total of 323 patients with IGH were included in this study (221 males [68.4%] and 102 females [31.6%]), with a median age of 73 (14–98) years. The patients were categorized into 2 groups: those who received bowel resection and those who did not require bowel resection during hernioplasty, as determined by clinical judgment of bowel ischemia during the operation. In total, 97 patients (30.0%) underwent bowel resection surgery and 226 (70.0%) did not. We used traditional non-mesh tissue repair techniques for hernioplasty such as Bassini or Shouldice procedure for inguinal hernia and McVay procedure for femoral hernia in patients with and without necrosis of hernia content, as demonstrated in Figure 1.^[15,16] Abdominal CT scanning was done in all patients and showed the following findings: 126 cases with multiple stepwise air-fluid levels and dilated bowel loops, 123 patients with thickening of bowel wall, 50 patients with ascites, and 8 patients with free intraperitoneal air. The proportion of patients undergoing bowel resection was 24.4% (54/221) in males and 42.2% (43/102) in females, both of which were statistically significant according to univariable analysis ($P=.001$). In addition, we found significant differences between the 2 groups of patients regarding rates of bowel obstruction, preoperative white blood cell count, preoperative neutrophilic leukocyte count, and preoperative NLR ($P<.05$) (Table 1).

A comparison of the continuous variables between the 2 groups showed that duration of incarceration, preoperative white blood cell count, preoperative neutrophilic leukocyte count, and preoperative NLR were all significantly higher in the patients with bowel resection than in patients without bowel resection ($P<.05$) (Table 2). The multivariate logistic regression analysis showed that NLR (odds ratio [OR]=3.362, 95% confidence interval [CI] 1.705–6.628, $P=.000$) and bowel obstruction (OR=3.191, 95% CI 1.873–5.437, $P=.000$) were independent risk factors for bowel resection in patients with IGH (Table 3).

4. Discussion

For patients with IGH, if bowel necrosis is confirmed or highly suspected intraoperatively, bowel resection should be performed immediately^[8]; the need for bowel resection significantly affects patient prognosis, with increased hospital stay, postoperative complications, and mortality.^[4,8,17] Therefore, it is of great clinical value to recognize risk factors which may predict need for bowel resection in patients with IGH. This study identifies risk factors of bowel resection based on multivariable logistic regression analysis results for 323 patients with IGH.

This study revealed that NLR and bowel obstruction were independent risk factors for bowel resection in patients with IGH. First, we found a relationship between an increased NLR and high risk of bowel resection. Moreover, our study revealed that if

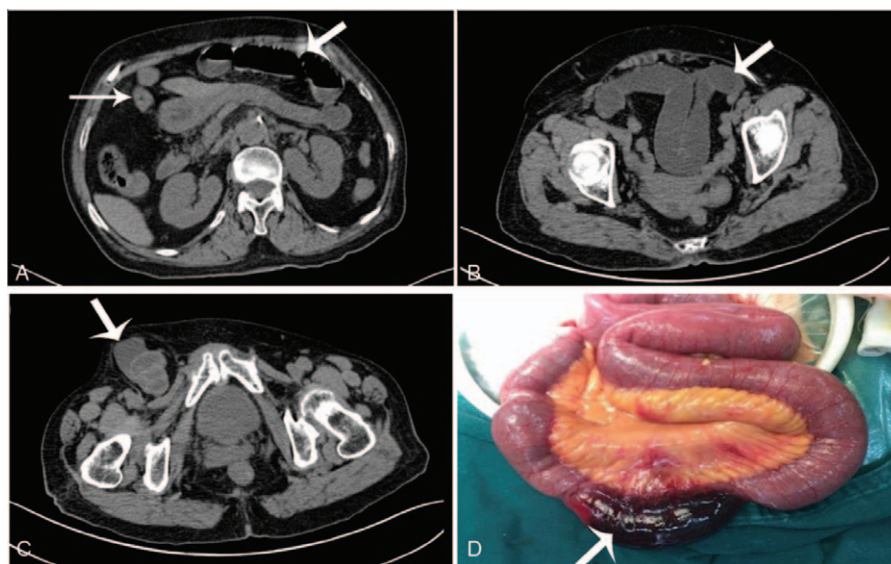


Figure 1. Description of emergency surgery of IGH. This was an 84-year-old female patient whose complaint was “groin pain, vomiting, and abdominal distension sustained for 14 hours” and diagnosed as incarcerated femoral hernia with bowel obstruction. (A–C) Horizontal view of abdominal CT scan. (D) Surgical exploration through the right inguinal incision. The white arrow in A and B shows the patients had bowel obstruction. The white arrow in C indicates the strangulated femoral hernia in the right-side groin area. The white arrow in D indicates the necrotic incarcerated small bowel. IGH = incarcerated groin hernia.

the NLR >6.5 , the probability of bowel necrosis was higher, suggesting that an NLR cutoff value of 6.5 could indicate that emergency surgery should be done immediately. Second, we identified bowel obstruction as an independent risk factor for bowel resection. Similar results were reported by several authors.^[6,7] Bowel ischemia caused by bowel obstruction may be responsible for this finding.

Available studies have provided strong evidences that when inflammation induces neutrophils rise and lymphocytes fall, leading to an elevated NLR.^[18–21] Previous researches have reported that NLR can be a good and valuable diagnostic indicator of the severity of inflammation. Ishizuka et al^[10] found that NLR ($\leq 8/\gt 8$) appear to be more sensitive and valuable than white blood cell count, neutrophil count, and C-reactive protein (CRP). Kahramanca et al^[22] reported that an NLR of 4.68 can aid to diagnose acute appendicitis and an NLR of 5.74 can differentiate between simple and complicated appendicitis. Shimizu et al^[12] discovered that NLR ($< 5/\geq 5$) may be more accurate and useful than the white blood cell count or CRP for diagnosis of severe appendicitis. In addition, Lee et al^[23] reported that preoperative NLR ≥ 3.0 was significantly associated with severe cholecystitis in patients undergoing cholecystectomy. In our study, we found that NLR ($\leq 6.5/\gt 6.5$) was the independent risk factor for bowel resection in patients with IGH. When incarcerated groin hernia is associated with bowel necrosis, which can lead to severe inflammatory response and an elevated NLR.

Currently, there are few reports on the relationship between NLR and bowel resection. Zhou et al^[24] found that NLR ($\leq 6.5/\gt 6.5$) was more closely associated with SGH than white blood cell count and neutrophils with higher sensitivity and specificity (0.75 and 0.689, respectively). Xie et al^[25] reported that NLR ($< 11.5/\geq 11.5$) could be used as the best predictor for diagnosing SGH. Koksai et al^[26] found that the risk of bowel necrosis was significantly higher when the NLR increased to 7.72 ± 5.69 ($P = .019$) and failed to give a cutoff value of NLR. However, the

sample size included in these 3 studies was relatively small, whereas the total number of samples included in our study was 323 and our results might be more reliable. We discovered that NLR ($\leq 6.5/\gt 6.5$) can be used as a good predictor for diagnosing bowel resection in patients with IGH. Still, a prospective cohort study is needed to evaluate NLR value in the diagnosis of bowel resection in patients with IGH.

Previous research has found statistically significant higher rates of bowel ischemia for females with IGH.^[6,8,27–30] However, other studies have argued that sex is not a risk factor for bowel resection in patients with IGH.^[4,7,9,25,31] Our results revealed that bowel resection occurred more often in female IGH patients than that in male patients with IGH; however, female sex was not an independent risk factor of bowel resection among patients with IGH according to our multivariable logistic regression analysis.

Although via multivariable regression analysis, our study found that age is not an independent risk factor for bowel resection, there has been significant debate on this issue. Previous research studies have found that advanced age was a predictor of bowel resection in patients with IGH,^[4,9,25,30] with Kurt et al’s finding that the rate of bowel resection in IGH patients older than 65 years was significantly higher than that in patients aged ≤ 65 years.^[8] Possible explanations include atypical signs and symptoms for elderly presentations of IGH, leading to delays in treatment and operation. Other studies have shown that advanced age was not a risk factor for bowel resection in patients with IGH.^[6–8,27,28,31]

There is also significant debate regarding duration of incarceration as a risk factor for bowel ischemia and subsequent bowel resection for patients with IGH.^[4,6,7,25,27,31] Our findings found late hospitalization to be a risk factor for bowel resection in patients with IGH in the analysis of continuous variables, but analysis of categorical variables revealed that duration of incarceration was not a risk factor for bowel resection in patients with IGH. This variable may be difficult to analyze, as patients may not remember the exact hour of onset for incarceration.

Table 1**Univariate analysis of the factors (categorical variables) affecting bowel resection in incarcerated groin hernia.**

Parameters	Bowel resection (n=97)	No bowel resection (n=226)	P
Sex			
Male	54 (55.7%)	167 (73.9%)	.001*
Female	43 (44.3%)	59 (26.1%)	
Age, y			
>57	85 (87.6%)	185 (81.9%)	.199
≤57	12 (12.4%)	44 (18.1%)	
Duration of incarceration, h			
>13	27 (27.8%)	61 (27.0%)	.876
≤13	70 (72.2%)	165 (73.0%)	
Admission season			.114
Autumn and winter	62 (63.9%)	123 (54.4%)	
Spring and summer	35 (36.1%)	103 (45.6%)	
Type of hernia			.013*
Indirect hernia	60 (61.9%)	168 (74.3%)	
Direct hernia	4 (4.1%)	15 (6.6%)	
Femoral hernia	33 (34.0%)	43 (19.0%)	
Bowel obstruction			.000*
Present	61 (62.9%)	65 (28.8%)	
Absent	36 (37.1%)	161 (71.2%)	
Previous abdominal surgery			.111
Present	10 (10.3%)	39 (17.3%)	
Absent	87 (89.7%)	187 (82.7%)	
Recurrent hernia			.243
Yes	7 (7.2%)	26 (11.5%)	
No	90 (92.8%)	200 (88.5%)	
Concomitant diseases (present)			
COPD (present)	23 (23.7%)	50 (22.1%)	.755
Multiple pregnancy (present)	1 (1.0%)	8 (3.5%)	.209
Liver cirrhosis or Liver cancer (present)	4 (4.1%)	13 (5.8%)	.548
Benign prostatic hyperplasia (present)	4 (4.1%)	10 (4.4%)	.903
White blood cell count ($\times 10^3$ cells/mm ³)			.000*
>8.5	70 (72.2%)	114 (50.4%)	
≤8.5	27 (27.8%)	112 (49.6%)	
Neutrophilic leukocyte count ($\times 10^3$ cells/mm ³)			.000*
>7	68 (70.1%)	108 (47.8%)	
≤7	29 (29.9%)	118 (52.2%)	
NLR			.000*
>6.5	78 (80.4%)	115 (50.9%)	
≤6.5	19 (19.6%)	111 (49.1%)	

Duration of incarceration: the period from the time when the mass is unable to reduce to the time of hospitalization. COPD = chronic obstructive pulmonary disease, NLR = neutrophil-to-lymphocyte ratio. * Statistically significant difference.

In addition, many studies have shown that femoral hernia is a risk factor for bowel resection in patients with IGH.^[4,6,8,9,27,28,30] Femoral hernias account for only 2.3% of elective hernias,^[32] but are usually present as incarcerated or strangulated with evidence of bowel necrosis, leading to severe morbidity and mortality.^[12,29,33,34] Anatomic reasons for the high incidences of incarceration may include the hard lacunar ligament, long and narrow femoral canal, and the structure of the femoral canal with small upper and large lower orifices. However, our study showed that although incarcerated femoral hernia patients were more susceptible to bowel resection, femoral hernia was not an independent risk factor for bowel resection. Additionally, the differences in the admission season, presence of previous abdominal surgery, presence of recurrent hernia, and presence of concomitant disease were not statistically significant between the 2 groups in our study.

Table 2**Univariate analysis of the factors (continuous variables) affecting bowel resection in incarcerated groin hernia.**

Parameters	Bowel resection (n=97)	No bowel resection (n=226)	P
Age, y	70.6 ± 14.6	69.6 ± 15.8	.616
Duration of incarceration, h	24 (4–240)	24 (3–360)	.009*
White blood cell count ($\times 10^3$ cells/mm ³)	10.2 (2.0–25.8)	8.5 (2.0–25.1)	.001*
Neutrophilic leukocyte count ($\times 10^3$ cells/mm ³)	8.5 (1.7–23.6)	6.8 (1.3–22.9)	.000*
NLR	10.4 (2.6–52.6)	6.7 (0.8–1016.7)	.000*

Duration of incarceration: the period from the time when the mass is unable to reduce to the time of hospitalization. NLR = neutrophil-to-lymphocyte ratio.

* Statistically significant difference.

Table 3**Binary logistic regression analysis of independent risk factors for bowel resection in incarcerated groin hernia.**

Variable	OR	95% CI	P
Sex (female/male)	1.564	0.830–2.947	.166
Bowel obstruction (present/absent)	3.191	1.873–5.437	.000*
Femoral hernia	1.644	0.819–3.301	.162
White blood cell count ($>8.5 \times 10^3 / \leq 8.75 \times 10^3$)	2.883	0.805–10.320	.104
Neutrophilic leukocyte count ($>7 \times 10^3 / \leq 7 \times 10^3$)	0.572	0.154–2.130	.405
NLR ($>6.5 / \leq 6.5$)	3.362	1.705–6.628	.000*

95% CI = 95% confidence interval, NLR = neutrophil-to-lymphocyte ratio, OR = Odds ratio.

* Statistically significant difference.

Lastly, there are inconsistent results regarding the predictive effects of white blood cell count and neutrophilic leukocyte count for bowel necrosis in patients with IGH. The results of Koizumi et al^[7] show that there was no statistically significant difference in white blood cell count and neutrophilic leukocyte count between the bowel resection group and no bowel resection group. However, Ge et al^[6] found that high levels of hematological markers such as white blood cell count and neutrophilic leukocyte count were associated with an increased risk of bowel resection. In our study, univariate analysis suggested that increased preoperative white blood cell count and preoperative neutrophilic leukocyte count were risk factors associated with bowel necrosis in IGH patients. Although multivariate analysis suggested that the above 2 factors were not independent predictors of bowel resection, the 2 indicators may help clinicians diagnose SGH.

The principal limitation of our study is that this was not a large-scale, multicenter prospective study. Due to the retrospective nature of our study, patient selection bias is inevitable, and future studies with large population samples and prospective study design are necessary for a better assessment of the risk factors discussed above.

5. Conclusions

An elevated NLR >6.5 and bowel obstruction are independent risk factors for bowel resection among patients with IGH. Surgeons should pay more attention on these patients and perform surgery promptly.

Acknowledgments

The authors thank Wordvice Company and Bonnie O. Wong (School of Medicine, Stanford University, 291 Campus Drive, Stanford, California, 94305, USA) for their assistance of language editing.

Author contributions

Conceptualization: Lie Yang, Yong Wang.

Data curation: Peng Chen, Wenming Yang, Jianhao Zhang.

Formal analysis: Lie Yang, Yong Wang.

Funding acquisition: Lie Yang.

Methodology: Peng Chen, Wenming Yang, Lie Yang, Yong Wang.

Project administration: Lie Yang.

Software: Peng Chen, Wenming Yang, Jianhao Zhang.

Supervision: Lie Yang, Yong Wang.

Writing – original draft: Peng Chen.

Writing – review & editing: Lie Yang, Yong Wang, Cun Wang, Yongyang Yu, Zongguang Zhou.

References

- Bay-Nielsen M, Kehlet H, Strand L, et al. Quality assessment of 26 304 herniorrhaphies in Denmark: a prospective nationwide study. *Lancet* 2001;358:0–1128.
- Dai W, Chen Z, Zuo J, et al. Risk factors of postoperative complications after emergency repair of incarcerated groin hernia for adult patients: a retrospective cohort study. *Hernia* 2019;23:267–76.
- Kulah B, Duzgun AP, Moran M, et al. Emergency hernia repairs in elderly patients. *Am J Surg* 2001;182:455–9.
- Abd Ellatif ME, Negm A, Elmorsy G, et al. Feasibility of mesh repair for strangulated abdominal wall hernias. *Int J Surg* 2012;10:153–6.
- Derici H, Unalp HR, Bozdogan AD, et al. Factors affecting morbidity and mortality in incarcerated abdominal wall hernias. *Hernia* 2007;11:341–6.
- Ge BJ, Huang Q, Liu LM, et al. Risk factors for bowel resection and outcome in patients with incarcerated groin hernias. *Hernia* 2010;14:259–64.
- Koizumi M, Sata N, Kaneda Y, et al. Optimal timeline for emergency surgery in patients with strangulated groin hernias. *Hernia* 2014;18:845–8.
- Kurt N, Oncel M, Ozkan Z, et al. Risk and outcome of bowel resection in patients with incarcerated groin hernias: retrospective study. *World J Surg* 2003;27:741–3.
- Sawayama H, Kanemitsu K, Okuma T, et al. Safety of polypropylene mesh for incarcerated groin and obturator hernias: a retrospective study of 110 patients. *Hernia* 2014;18:399–406.
- Bessa SS, Abdel-fattah MR, Al-Sayes IA, et al. Results of prosthetic mesh repair in the emergency management of the acutely incarcerated and/or strangulated groin hernias: a 10-year study. *Hernia* 2015;19:909–14.
- Venara A, Hubner M, Le Naoures P, et al. Surgery for incarcerated hernia: short-term outcome with or without mesh. *Langenbecks Arch Surg* 2014;399:571–7.
- Alimoglu O, Kaya B, Okan I, et al. Femoral hernia: a review of 83 cases. *Hernia* 2006;10:70–3.
- Chen P, Huang L, Yang W, et al. Risk factors for bowel resection among patients with incarcerated groin hernias: A meta-analysis. *Am J Emerg Med* 2020;38:376–83.
- Youden WJ. Index for rating diagnostic tests. *Cancer* 1950;3:32–5.
- Compagna R, Rossi R, Fappiano F, et al. Emergency groin hernia repair: implications in elderly. *BMC Surg* 2013;13(suppl 2):S29.
- Elsebae M. Tension-free repair versus Bassini technique for strangulated inguinal hernia: A controlled randomized Study. *Int J Surg* 2008;6:302–5.
- Kulah B, Polat Duzgun A, Moran M, et al. Emergency hernia repairs in elderly patients. *Am J Surg* 2001;182:455–9.
- Kay HD, Smith DL. Regulation of human lymphocyte-mediated natural killer (NK) cell activity. I. Inhibition in vitro by peripheral blood granulocytes. *J Immunol* 1983;130:475–83.
- Nathan C. Neutrophils and immunity: challenges and opportunities. *Nat Rev Immunol* 2006;6:173–82.
- Patek PQ, Collins JL, Cohn M. Evidence that cytotoxic T cells and natural cytotoxic cells use different lytic mechanisms to lyse the same targets. *Eur J Immunol* 1983;13:433–6.
- Petrie HT, Klassen LW, Kay HD. Inhibition of human cytotoxic T lymphocyte activity in vitro by autologous peripheral blood granulocytes. *J Immunol* 1985;134:230–4.
- Kahraman S, Ozgehan G, Seker D, et al. Neutrophil-to-lymphocyte ratio as a predictor of acute appendicitis. *Ulus Travma Acil Cerrahi Derg* 2014;20:19–22.
- Lee SK, Lee SC, Park JW, et al. The utility of the preoperative neutrophil-to-lymphocyte ratio in predicting severe cholecystitis: a retrospective cohort study. *BMC Surg* 2014;14:100.
- Zhou H, Ruan X, Shao X, et al. Clinical value of the neutrophil/lymphocyte ratio in diagnosing adult strangulated inguinal hernia. *Int J Surg* 2016;36:76–80.
- Xie X, Feng S, Tang Z, et al. Neutrophil-to-lymphocyte ratio predicts the severity of incarcerated groin hernia. *Med Sci Monit* 2017;23:5558–63.
- Koksak H, Ates D, Nazik EE, et al. Predictive value of preoperative neutrophil-to-lymphocyte ratio while detecting bowel resection in hernia with intestinal incarceration. *Ulus Travma Acil Cerrahi Derg* 2018;24:207–10.
- Tanaka N, Uchida N, Ogihara H, et al. Clinical study of inguinal and femoral incarcerated hernias. *Surg Today* 2010;40:1144–7.
- Alvarez JA, Baldonado RF, Bear IG, et al. Incarcerated groin hernias in adults: presentation and outcome. *Hernia* 2004;8:121–6.
- Kulah B, Kulacoglu IH, Oruc MT, et al. Presentation and outcome of incarcerated external hernias in adults. *Am J Surg* 2001;181:101–4.
- Tatar C, Tüzün İS, Karşıdağ T, et al. Prosthetic Mesh Repair for Incarcerated Inguinal Hernia. *Balkan Med J* 2016;33:434–40.
- Atila K, Guler S, Inal A, et al. Prosthetic repair of acutely incarcerated groin hernias: a prospective clinical observational cohort study. *Langenbecks Arch Surg* 2010;395:563–8.
- Glassow F. Femoral hernia. Review of 2,105 repairs in a 17 year period. *Am J Surg* 1985;150:353–6.
- Alhambra-Rodriguez de Guzmán C, Picazo-Yeste J, Tenías-Burillo JM, et al. Improved outcomes of incarcerated femoral hernia: a multivariate analysis of predictive factors of bowel ischemia and potential impact on postoperative complications. *Am J Surg* 2013;205:188–93.
- Oishi SN, Page CP, Schwesinger WH. Complicated presentations of groin hernias. *Am J Surg* 1991;162:568–71.