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Contents

Thrice Monthly Volume 9 Number 35 December 16, 2021

REVIEW

- 10746** Management of acute kidney injury in gastrointestinal tumor: An overview

Su YQ, Yu YY, Shen B, Yang F, Nie YX

- 10765** Application of vascular endothelial cells in stem cell medicine

Liang QQ, Liu L

MINIREVIEWS

- 10781** Application of traditional Chinese medicine in treatment of *Helicobacter pylori* infection

Li RJ, Dai YY, Qin C, Huang GR, Qin YC, Huang YY, Huang ZS, Luo XK, Huang YQ

ORIGINAL ARTICLE

Case Control Study

- 10792** Impact of cytomegalovirus infection on biliary disease after liver transplantation - maybe an essential factor

Liu JY, Zhang JR, Sun LY, Zhu ZJ, Wei L, Qu W, Zeng ZG, Liu Y, Zhao XY

- 10805** Blood tests for prediction of deep endometriosis: A case-control study

Chen ZY, Zhang LF, Zhang YQ, Zhou Y, Li XY, Huang XF

Retrospective Cohort Study

- 10816** Association between neutrophil-to-lymphocyte ratio and major postoperative complications after carotid endarterectomy: A retrospective cohort study

Yu Y, Cui WH, Cheng C, Lu Y, Zhang Q, Han RQ

- 10828** Application of MAGnetic resonance imaging compilation in acute ischemic stroke

Wang Q, Wang G, Sun Q, Sun DH

Retrospective Study

- 10838** Ninety-four thousand-case retrospective study on antibacterial drug resistance of *Helicobacter pylori*

Zhang Y, Meng F, Jin J, Wang J, Gu BB, Peng JB, Ye LP

- 10850** Adjacent segment disease following Dynesys stabilization for lumbar disorders: A case series of mid- and long-term follow-ups

Chen KJ, Lai CY, Chiu LT, Huang WS, Hsiao PH, Chang CC, Lin CJ, Lo YS, Chen YJ, Chen HT

- 10861** Identification of independent risk factors for intraoperative gastroesophageal reflux in adult patients undergoing general anesthesia

Zhao X, Li ST, Chen LH, Liu K, Lian M, Wang HJ, Fang YJ

- 10871** Value of the controlling nutritional status score and psoas muscle thickness per height in predicting prognosis in liver transplantation

Dai X, Gao B, Zhang XX, Li J, Jiang WT

- 10884** Development of a lipid metabolism-related gene model to predict prognosis in patients with pancreatic cancer

Xu H, Sun J, Zhou L, Du QC, Zhu HY, Chen Y, Wang XY

- 10899** Serum magnesium level as a predictor of acute kidney injury in patients with acute pancreatitis

Yu XQ, Deng HB, Liu Y, Qu C, Duan ZH, Tong ZH, Liu YX, Li WQ

- 10909** Pedicle complex tissue flap transfer for reconstruction of duplicated thumbs with unequal size

Wang DH, Zhang GP, Wang ZT, Wang M, Han QY, Liu FX

- 10919** Minimally invasive surgery *vs* laparotomy in patients with colon cancer residing in high-altitude areas

Suo Lang DJ, Ci Ren YZ, Bian Ba ZX

Observational Study

- 10927** Surgery for chronic pancreatitis in Finland is rare but seems to produce good long-term results

Parhiala M, Sand J, Laukkanen J

- 10937** Association of overtime work and obesity with needle stick and sharp injuries in medical practice

Chen YH, Yeh CJ, Jong GP

- 10948** Serum gastrin-17 concentration for prediction of upper gastrointestinal tract bleeding risk among peptic ulcer patients

Wang JX, Cao YP, Su P, He W, Li XP, Zhu YM

- 10956** Predictive risk scales for development of pressure ulcers in pediatric patients admitted to general ward and intensive care unit

Luo WJ, Zhou XZ, Lei JY, Xu Y, Huang RH

META-ANALYSIS

- 10969** Clinical significance of signet ring cells in surgical esophageal and esophagogastric junction adenocarcinoma: A systematic review and meta-analysis

Wang YF, Xu SY, Wang Y, Che GW, Ma HT

- 10979** Percutaneous biliary stent combined with brachytherapy using ¹²⁵I seeds for treatment of unresectable malignant obstructive jaundice: A meta-analysis

Chen WY, Kong CL, Meng MM, Chen WQ, Zheng LY, Mao JT, Fang SJ, Chen L, Shu GF, Yang Y, Weng QY, Chen MJ, Xu M, Ji JS

CASE REPORT

- 10994** Prenatal ultrasonographic findings in Klippel-Trenaunay syndrome: A case report

Pang HQ, Gao QQ

- 10999** Immunoglobulin G4-related lymph node disease with an orbital mass mimicking Castleman disease: A case report
Hao FY, Yang FX, Bian HY, Zhao X
- 11007** Treatment for subtrochanteric fracture and subsequent nonunion in an adult patient with osteopetrosis: A case report and review of the literature
Yang H, Shao GX, Du ZW, Li ZW
- 11016** Early surgical intervention in culture-negative endocarditis of the aortic valve complicated by abscess in an infant: A case report
Yang YF, Si FF, Chen TT, Fan LX, Lu YH, Jin M
- 11024** Severe absence of intra-orbital fat in a patient with orbital venous malformation: A case report
Yang LD, Xu SQ, Wang YF, Jia RB
- 11029** Pulmonary Langerhans cell histiocytosis and multiple system involvement: A case report
Luo L, Li YX
- 11036** Complete androgen insensitivity syndrome caused by the c.2678C>T mutation in the androgen receptor gene: A case report
Wang KN, Chen QQ, Zhu YL, Wang CL
- 11043** Ultrasound guiding the rapid diagnosis and treatment of perioperative pneumothorax: A case report
Zhang G, Huang XY, Zhang L
- 11050** Chronic colchicine poisoning with neuromyopathy, gastric ulcers and myelosuppression in a gout patient: A case report
Li MM, Teng J, Wang Y
- 11056** Treatment of a giant low-grade appendiceal mucinous neoplasm: A case report
Xu R, Yang ZL
- 11061** Thoracoscopic resection of a large lower esophageal schwannoma: A case report and review of the literature
Wang TY, Wang BL, Wang FR, Jing MY, Zhang LD, Zhang DK
- 11071** Signet ring cell carcinoma hidden beneath large pedunculated colorectal polyp: A case report
Yan JN, Shao YF, Ye GL, Ding Y
- 11078** Double-mutant invasive mucinous adenocarcinoma of the lung in a 32-year-old male patient: A case report
Wang T
- 11085** Acute myocarditis presenting as accelerated junctional rhythm in Graves' disease: A case report
Li MM, Liu WS, Shan RC, Teng J, Wang Y
- 11095** Lingual nerve injury caused by laryngeal mask airway during percutaneous nephrolithotomy: A case report
Wang ZY, Liu WZ, Wang FQ, Chen YZ, Huang T, Yuan HS, Cheng Y

- 11102** Ventricular fibrillation and sudden cardiac arrest in apical hypertrophic cardiomyopathy: Two case reports
Park YM, Jang AY, Chung WJ, Han SH, Semsarian C, Choi IS
- 11108** *Rhizopus microsporus* lung infection in an immunocompetent patient successfully treated with amphotericin B: A case report
Chen L, Su Y, Xiong XZ
- 11115** Spermatocytic tumor: A rare case report
Hao ML, Li CH

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Retrospective Study

Minimally invasive surgery vs laparotomy in patients with colon cancer residing in high-altitude areas

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Abstract

BACKGROUND

Colon cancer is associated with a higher incidence among residents in high-altitude areas. Hypoxic environment at high altitudes inhibits the phagocytic and oxygen-dependent killing function of phagocytes, thereby increasing the inflammatory factors, inhibiting the body's innate immunity and increasing the risk of colon cancer.

AIM

To examine the effect of minimally invasive surgery *vs* laparotomy in patients with colon cancer residing in high-altitude areas.

METHODS

Ninety-two patients with colon cancer in our hospital from January 2019 to February 2021 were selected and divided into the minimally invasive surgery and laparotomy groups using the random number table method, with 46 patients in each group. Minimally invasive surgery was performed in the minimally invasive group and laparotomy in the laparotomy group. Operative conditions, inflammatory index pre- and post-surgery, immune function index and complication probability were measured.

RESULTS

Operative duration was significantly longer and intraoperative blood loss and recovery time of gastrointestinal function were significantly less (all $P < 0.05$) in the minimally invasive group than in the laparotomy group. The number of lymph nodes dissected was not significantly different. Before surgery, there were no significant differences in serum C-reactive protein, interleukin-6 and tumor necrosis factor- α levels between the groups, whereas after surgery, the levels were

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significantly higher in the minimally invasive group (26.98 ± 6.91 mg/L, 146.38 ± 11.23 ng/mL and 83.51 ± 8.69 pg/mL *vs* 41.15 ± 8.39 mg/L, 186.79 ± 15.36 ng/mL and 110.65 ± 12.84 pg/mL, respectively, $P < 0.05$). Furthermore, before surgery, there were no significant differences in CD3+, CD4+ and CD4+/CD8+ levels between the groups, whereas after surgery, the levels decreased in both groups, being significantly higher in the minimally invasive group ($55.61\% \pm 4.39\%$, $35.45\% \pm 3.67\%$ and 1.30 ± 0.35 *vs* $49.68\% \pm 5.33\%$, $31.21\% \pm 3.25\%$ and 1.13 ± 0.30 , respectively, $P < 0.05$). Complication probability was significantly lower in the minimally invasive group (4.35% *vs* 17.39% , $P < 0.05$).

CONCLUSION

Laparoscopic minimally invasive procedures reduce surgical trauma and alleviate the inflammatory response and immune dysfunction caused by invasive operation. It also shortens recovery time and reduces complication probability.

Key Words: Minimally invasive surgery; Laparotomy; High-altitude area; Colon cancer; Surgical trauma; Immune dysfunction

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Core Tip: The incidence of colon cancer in high altitude areas is relatively high. We aimed to compare the curative effect of open surgery and laparoscopic surgery in high altitude areas through this study and provide evidence for the diagnosis and treatment of colon cancer in high altitude areas.

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INTRODUCTION

Colon cancer is a multiple malignant tumor of the digestive system that is associated with a higher incidence among residents in high-altitude areas. People living in these areas like to eat dairy products and red meat but consume less fruits and vegetables, so the risk of colon cancer is greater, which poses a great threat to the physical and mental health of these patients and to their quality of life[1]. A study by Frisncho *et al* [2] found that the hypoxic environment at high altitudes inhibits the phagocytic and oxygen-dependent killing function of phagocytes, thereby increasing the number of inflammatory factors such as interleukin-6 (IL-6), inhibiting the body's innate immunity and increasing the risk of colon cancer. In recent years, due to the increasing incidence of colon cancer, the safe and effective treatment have become a research hotspot[3,4].

If colon cancer is not treated timely and effectively, it results in lesion metastasis, making treatment more difficult, with worse prognosis[5,6]. Therefore, after the diagnosis of colon cancer, timely selection of the best surgical plan is vital in the treatment of these patients. Surgery is an important measure in the current clinical treatment of colon cancer, and laparotomy and laparoscopic minimally invasive surgery are commonly used[7,8]. Complete circumferential mesorectal excision is the standard treatment for colon cancer. Traditional laparotomy can be performed under direct vision and achieves certain results. However, the larger surgical trauma and higher complication probability are not conducive to the body's functional recovery[9-11]. With improvements in minimally invasive technology and the popularization of this concept, laparoscopic surgery has been applied as an important clinical minimally invasive surgery in colon cancer. This surgery can reduce surgical trauma and shorten recovery time, which play an important role in the treatment[12-14].

Here, we aimed to study the application of minimally invasive surgery and laparotomy in patients with colon cancer residing in high-altitude areas.

MATERIALS AND METHODS

General information

This study was approved by the ethics committee of our hospital. Ninety-two patients with colon cancer in our hospital from January 2019 to February 2021 were selected and divided into the minimally invasive and laparotomy groups using the random number table method, with 46 patients in each group.

In the minimally invasive group, there were 25 males and 21 females. The average age was 57.56 ± 10.91 (range: 44–71) years. In 22 patients, the Dukes stage was stage A, for 19 patients, stage B and for 5 patients, stage C. The tumor diameter was between 3.8 cm and 6.2 cm, with an average of 5.06 ± 1.10 cm. The tumor location was the cecum (in 27 patients), colon ascendens (14 patients), hepatic flexure of the colon (3 patients) and colon transversum (2 patients).

In the laparotomy group, there were 29 males and 17 females. The average age was 59.06 ± 12.11 (range: 42–76) years. In 24 patients, the Dukes stage was stage A, in 18 patients, stage B and in 4 patients, stage C. The tumor diameter ranged from 4.1 cm to 6.5 cm, with an average of 5.31 ± 1.05 cm. The tumor location was the cecum (in 24 patients), colon ascendens (15 patients), hepatic flexure of the colon (3 patients) and colon transversum (4 patients).

Selection criteria

Patients were included if: (1) The disease met the diagnostic criteria of colon cancer in surgery[15]; (2) The tumor had been confirmed *via* colonoscopy and other examinations; (3) The tumor had not been preoperatively treated; (4) The tumor could be resected after computed tomography and evaluation; (5) They lived in high-altitude areas; and (6) They provided informed consent to this study. Patients with: (1) Other benign and malignant tumors; (2) Metastatic lesions; (3) Cardiopulmonary dysfunction and inability to fully tolerate surgery; (4) Anemia and malnutrition; (5) Mental disorders; and (6) Poor compliance and inability to cooperate with investigators to complete the investigation were excluded.

Laparotomy group

In this group, laparotomy was performed. Patients were placed in the supine position for general anesthesia. The location of the tumor and surgical incision were determined. The incision was selected near the rectus abdominis, and the upper and lower intestinal tubes and vessels at the mesangial root of the tumor were ligated. The affected intestine was dissociated, the mesentery and intestine were dissected, and the intestine was sutured and fixed. The intestinal tube was clipped approximately 5 cm below the mass to check the blood supply. The enterocoelitis was cleaned, a drainage tube was placed, and sutures were applied.

Minimally invasive group

In this group, minimally invasive surgery (laparoscopic radical operation) was performed. Patients were assisted to take the supine position for general anesthesia, and CO₂ artificial pneumoperitoneum was established to maintain the pneumoperitoneum pressure at 13–15 mmHg. The laparoscope and trocar were placed to investigate the internal conditions of the enterocoelitis, including the lesion location, volume, metastasis and invasion. According to the treatment requirements, the colonic mesentery, peritoneum and omentum were dissociated, and the colonic mesentery was dissociated to the corresponding vascular root of the lesion. A small incision was made in the middle of the abdominal wall, and the mesangial membrane and blood vessels of the intestine were separated. If the patient had colonic convoluted tumor, the pancreatic head, gastric omentum vessels and lymph nodes under the pylorus were simultaneously removed to remove the affected tissue and tumor. The distal colon was anastomosed using a stapler and returned to the enterocoelitis with intermittent suture between the peritoneum and mesentery. The incision was cleaned, and sutures were applied. Both groups were administered antibiotics for infection prevention and control after surgery.

Data analyze

The surgical conditions in the two groups, including duration, intraoperative blood loss, recovery time of gastrointestinal function and number of lymph nodes dissected were measured. The inflammatory factor [C-reactive protein (CRP), IL-6, tumor necrosis factor- α (TNF- α)] levels were measured before and after surgery in the groups. We extracted 4 mL of fasting venous blood and centrifuged it at 3000 r/min

for 15 min. The supernatant was taken and analyzed using enzyme-linked immunosorbent assay. The immune function index (CD3+, CD4+, CD4+/CD8+) before and after surgery was determined. Blood samples were taken and measured using the FACSCANTO II flow cytometry (BD Company, United States). The complication probability in the two groups was analyzed.

Statistical analysis

SPSS22.0 was used for data analysis. The measurement data were expressed as means \pm SD and were compared using *t* test. The enumeration data were expressed as *n* (%) and were compared using the χ^2 test. $P < 0.05$ indicated a statistically significant difference.

RESULTS

Clinical data for gender, age, Dukes stage, tumor diameter and tumor location were comparable between the groups ($P > 0.05$).

Comparison of surgical conditions

The operative duration was longer in the minimally invasive group (189.39 ± 20.38 min) than in the laparotomy group (145.62 ± 16.37 min), whereas intraoperative blood loss and recovery time of gastrointestinal function were less in the minimally invasive group than in the laparotomy group (101.26 ± 18.64 mL and 2.55 ± 0.39 d *vs* 153.22 ± 23.39 mL and 3.37 ± 0.46 d, respectively, $P < 0.05$). The number of lymph nodes dissected was not significantly different between the minimally invasive (14.26 ± 3.15) and laparotomy (15.51 ± 3.49 , $P > 0.05$) groups (Table 1).

Comparison of inflammatory factors before and after surgery

Before surgery, there were no significant differences in the serum CRP, IL-6 and TNF- α levels between the groups (9.18 ± 3.38 mg/L, 122.33 ± 16.19 ng/mL and 76.37 ± 11.25 pg/mL *vs* 8.97 ± 3.60 mg/L, 119.64 ± 18.02 ng/mL and 78.62 ± 13.18 pg/mL, respectively, $P > 0.05$); after surgery, these levels were significantly higher in the minimally invasive group than in the laparotomy group (26.98 ± 6.91 mg/L, 146.38 ± 11.23 ng/mL and 83.51 ± 8.69 pg/mL *vs* 41.15 ± 8.39 mg/L, 186.79 ± 15.36 ng/mL and 110.65 ± 12.84 pg/mL, respectively, $P < 0.05$) (Table 2).

Comparison of the immune function index before and after surgery

Before surgery, there were no significant differences in CD3+, CD4+ and CD4+/CD8+ counts between the groups ($61.23\% \pm 6.45\%$, $40.26\% \pm 4.11\%$ and 1.58 ± 0.50 *vs* $63.09\% \pm 5.96\%$, $39.64\% \pm 3.89\%$ and 1.62 ± 0.44 , respectively, $P > 0.05$); after surgery, the counts were lower in both groups, with CD3+, CD4+ and CD4+/CD8+ counts being significantly higher in the minimally invasive group than in the laparotomy group ($55.61\% \pm 4.39\%$, $35.45 \pm 3.67\%$ and 1.30 ± 0.35 *vs* $49.68\% \pm 5.33\%$, $31.21\% \pm 3.25\%$ and 1.13 ± 0.30 , respectively, $P < 0.05$) (Table 3).

Comparison of complication probability

The complication probability was significantly lower in the minimally invasive group (4.35%) than in the laparotomy group (17.39%; $P < 0.05$, Table 4).

DISCUSSION

In this study, we performed minimally invasive surgery and laparotomy for the treatment of colon cancer in patients from our hospital who were residing in high-altitude areas. The operative duration was significantly longer in the minimally invasive group, but there was no significant difference in the number of lymph nodes dissected between the groups. The amount of intraoperative blood loss was less and recovery time of gastrointestinal function was shorter in the minimally invasive group. Biondo *et al* [16] reported no significant difference between laparoscopic and laparotomy in lymph node dissection in patients with colon cancer. Although laparoscopic surgery takes longer, it is associated with less blood loss and shorter recovery time of gastrointestinal function. This is consistent with the findings from this study, suggesting that minimally invasive surgery can achieve the same effect on lymph node dissection as open surgery in patients with colorectal cancer residing in high-altitude

Table 1 Surgical conditions in the two groups (mean \pm SD)

Group	Number of cases	Surgery duration (min)	Intraoperative blood loss (mL)	Gastrointestinal function recovery time (d)	Number of lymph node dissection
Minimally invasive group	46	189.39 \pm 20.38	101.26 \pm 18.64	2.55 \pm 0.39	14.26 \pm 3.15
Laparotomy group	46	145.62 \pm 16.37	153.22 \pm 23.39	3.37 \pm 0.46	15.51 \pm 3.49
<i>t</i> value		11.356	11.783	9.222	1.803
<i>P</i> value		0.000	0.000	0.000	0.075

Table 2 Inflammatory factors before and after surgery in the two groups (mean \pm SD)

Time	Group	<i>n</i>	CRP (mg/L)	IL-6 (ng/mL)	TNF- α (pg/mL)
Before Surgery	Minimally invasive group	46	9.18 \pm 3.38	122.33 \pm 16.19	76.37 \pm 11.25
	Laparotomy group	46	8.97 \pm 3.60	119.64 \pm 18.02	78.62 \pm 13.18
	<i>t</i> value		0.288	0.753	0.881
	<i>P</i> value		0.774	0.453	0.381
After Surgery	Minimally invasive group	46	26.98 \pm 6.91	146.38 \pm 11.23	83.51 \pm 8.69
	Laparotomy group	46	41.15 \pm 8.39	186.79 \pm 15.36	110.65 \pm 12.84
	<i>t</i> value		8.842	14.404	11.872
	<i>P</i> value		0.000	0.000	0.000

CRP: C-reactive protein; IL-6: Interleukin-6; TNF- α : Tumor necrosis factor- α .

Table 3 Immune function indexes in the two groups before and after surgery (mean \pm SD)

Time	Group	<i>n</i>	CD3 ⁺ (%)	CD4 ⁺ (%)	CD4 ⁺ /CD8 ⁺
Before Surgery	Minimally invasive group	46	61.23 \pm 6.45	40.26 \pm 4.11	1.58 \pm 0.50
	Laparotomy group	46	63.09 \pm 5.96	39.64 \pm 3.89	1.62 \pm 0.44
	<i>t</i> value		1.436	0.743	0.407
	<i>P</i> value		0.154	0.459	0.685
After Surgery	Minimally invasive group	46	55.61 \pm 4.39	35.45 \pm 3.67	1.30 \pm 0.35
	Laparotomy group	46	49.68 \pm 5.33	31.21 \pm 3.25	1.13 \pm 0.30
	<i>t</i> value		5.825	5.866	2.501
	<i>P</i> value		0.000	0.000	0.014

regions and can reduce surgical trauma and shorten the time for functional rehabilitation. Because laparotomy is mature and can be performed under direct vision, the effect of lymph node dissection is ideal. However, laparoscopic minimally invasive surgery can be performed with the help of endoscopic amplification function, providing surgeons with a clear surgical field. It is beneficial to ensure the precision of anatomical separation, obtain sufficient tumor incisional margin and reduce trauma, which promote body function and recovery time shortening. However, laparoscopic surgery has high requirements for the operator's skills, and the uterus, small intestine and other adjacent organs during the operation will affect the operation, which prolongs the operation time to a certain extent[17,18].

Invasive surgery can activate the hypothalamic-pituitary-adrenal cortical system and promote the production of TNF- α , IL-6, cortisol and norepinephrine. CRP is also an important indicator for clinical evaluation of the degree of trauma in the body, which can reflect the degree of inflammation *in vivo*. Our results showed that CRP, IL-6 and TNF- α levels in the minimally invasive group were lower than those in the open

Table 4 Complication probability in the two groups, *n* (%)

Group	<i>n</i>	Infection	Anastomotic leakage	Urinary retention	Intestinal obstruction	Total Incidence
Minimally invasive group	46	1 (2.17)	0 (0.00)	1 (2.17)	0 (0.00)	2 (4.35)
Laparotomy group	46	3 (6.52)	2 (4.35)	1 (2.17)	2 (4.35)	8 (17.39)
χ^2 value						4.039
<i>P</i> value						0.044

group, which is consistent with the findings from Takemasa *et al*[19].

From the microscopic perspective of serum factors, it has been proven that laparoscopic surgery has a higher application value in cases of colon cancer in patients residing in high-altitude regions than open surgery, which can reduce the degree of inflammatory stress response caused by surgical invasive trauma and ensure safe treatment. CD3+, CD4+ and CD4+/CD8+ are important immune cells in the body. CD3+ cells are active cells that can reflect the expression of mature lymphocytes in the peripheral blood. CD4+ cells are helper T cells, whereas CD8+ cells are cytotoxic T cells. CD4+/CD8+ can reflect the immune function of the body. Studies have shown that T cells can mediate cellular immunity *in vivo*, and changes in the function and quantity of T cells are key indicators to evaluate cellular immunity. The stronger the function of T cells after colon cancer surgery, the better it can help patients eliminate residual tumor cells in the body and maintain the body's immune function[20].

The results of this study showed that CD3+, CD4+ and CD4+/CD8+ levels in the two groups after the surgery were lower than those before surgery, but the levels of all the indicators were higher in the minimally invasive group than in the open group, indicating that laparoscopic surgery imparts less damage to the immune system of patients with colon cancer residing in high-altitude areas than open surgery and is of great significance in the postoperative recovery of these patients' body functions. This is probably because laparoscopic surgery requires a small incision, which causes less damage to the body, and the inflammatory stress response caused by the invasive operation during the operation is less, which has less impact on the immune system function[21].

In addition, our findings also showed that the incidence of complications was significantly lower in the minimally invasive group than in the laparotomy group. Thus, laparoscopic surgery also has significant advantages in reducing the risk of complication probability in patients with colon cancer residing in high-altitude areas, which can ensure the effectiveness and safety of treatment of colon cancer in these patients.

CONCLUSION

Laparoscopic surgery for colon cancer in patients residing in high-altitude areas can reduce surgical trauma, alleviate inflammatory response and immune dysfunction caused by invasive surgery and thereby shorten the recovery time of body functions and reduce the risk of complications in these patients.

ARTICLE HIGHLIGHTS

Research background

Hypoxic environment at high altitudes increases the risk of colon cancer.

Research motivation

This study investigated the advantages of laparoscopic surgery in the treatment of colon cancer in the plateau area.

Research objectives

The authors aimed to examine the effect of minimally invasive surgery *vs* laparotomy in patients with colon cancer residing in high-altitude areas.

Research methods

Ninety-two patients with colon cancer were included. The surgical conditions in the two groups, including duration, intraoperative blood loss, recovery time of gastrointestinal function and number of lymph nodes dissected, were measured. The inflammatory factor levels were measured before and after surgery in the groups. The immune function index before and after surgery was determined.

Research results

The operative duration was longer in the minimally invasive group than in the laparotomy group, whereas intraoperative blood loss and recovery time of gastrointestinal function were less in the minimally invasive group than in the laparotomy group. After surgery, these levels were significantly higher in the minimally invasive group than in the laparotomy group. The counts were lower in both groups, with CD3+, CD4+, and CD4+/CD8+ counts being significantly higher in the minimally invasive group than in the laparotomy group.

Research conclusions

The results suggest that the laparoscopic surgery for colon cancer in patients residing in high-altitude areas can reduce surgical trauma, alleviate inflammatory response and immune dysfunction caused by invasive surgery and thereby shorten the recovery time of body functions and reduce the risk of complications in these patients.

Research perspectives

The advantages of laparoscopic surgery for patients with other diseases can be explored in the future.

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