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Original Article

Application of intra-abdominal pressure monitoring in early enteral nutrition after abdominal surgery

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Abstract: Objective: To explore the effect of intra-abdominal pressure monitoring in early enteral nutrition therapy after abdominal surgery. Methods: 164 patients who underwent elective abdominal surgery in our hospital from January 2019 to January 2020 were selected and divided into an observation group and a control group according to the random number table method, with 82 cases in each group. On the basis of conventional enteral nutrition nursing, the control group received conventional gastric residual monitoring, and the observation group received intra-abdominal pressure monitoring. The clinical treatment effect, intra-abdominal pressure, incidence of intra-abdominal hypertension, APACHE-II score, and enteral nutrition tolerance were compared. Correlation of early enteral nutrition intolerance and intra-abdominal pressure was analyzed in the ROC curve. Results: The time of abdominal pain relief, adjusted enteral nutrition, and hospitalization were significantly shorter in the observation group ($P < 0.05$). The intra-abdominal pressure, intra-abdominal hypertension rate, and APACHE-II scores were comparable before treatment ($P > 0.05$) and all were significantly reduced after treatment in the two groups ($P < 0.05$). After treatment, the above items were significantly lower in the observation group ($P < 0.05$). The enteral nutrition's tolerance level of the observation group was significantly higher than that of the control group ($P < 0.05$). The Pearson correlation analysis revealed that the early enteral nutrition tolerance of patients after abdominal surgery was correlated with the level of intra-abdominal pressure ($P < 0.05$). The ROC reveled that the baseline level of intra-abdominal pressure and the average level of intra-abdominal pressure 3 days before enteral nutrition were of diagnostic values in predicting the intolerance during enteral nutrition. Conclusion: Intraperitoneal pressure monitoring can significantly improve patients' symptoms, and it should be accurately measured for doctors to make timely diagnoses and provide proper treatments.

Keywords: Intra-abdominal pressure monitoring, abdominal surgery, early enteral nutrition, treatment

Introduction

Abdominal surgery is considered one of the most common clinical surgeries. The particularity of the abdominal cavity's structure may incur multiple complications after surgery. The severe trauma of common gastrointestinal surgeries can make patients have a systematic stress response, which slows down bowel movements' speed and impairs intestinal mucosal function [1]. The impairment of intestinal mucosa can boost the permeability and cause massive bacterial translocation reproduction. The severe cases may be accompanied by systemic inflammatory response syndrome [2]. Early enteral nutrition therapy is extensively applied in clinical treatments. It can protect gastrointestinal mucosa, enhance body immunity function, provide essential nutrient metabolism for patients and prevent the occurrence of gastrointestinal complications [3]. However, during enteral nutrition therapy, patients are prone to having intolerant symptoms like diarrhea, abdominal pain, and vomiting. Therefore, it will prolong patients' intestinal function recovery time and hospitalization time [4]. In clinical treatments, residual gastric monitoring is applied to identify the tolerance to enteral nutrition. However, it could induce come complications, like vomiting, and in some patients,

fail to clarify the adjusted enteral nutrition time and improve patients' tolerance. Thus, effective clinical treatments should be conducted to avoid early enteral nutrition intolerance after abdominal surgery. Studies have shown that [5] intra-abdominal pressure monitoring can help medical staff understand patients' gastrointestinal intolerance. However, there has been little research on the effects of intra-abdominal pressure monitoring in early enteral nutrition therapy after abdominal surgery. From January 2019 to January 2020, we choose 164 inpatients who underwent elective abdominal surgery in our hospital as the research objects. The following research was conducted to explore the effect of intra-abdominal pressure monitoring in early enteral nutrition therapy after abdominal surgery.

Materials and methods

Clinical data and information collection

From January 2019 to January 2020, we selected 164 inpatients who underwent elective abdominal surgery as the research objects. Inclusion criteria: 1. Accepted elective abdominal surgery; 2. 30 to 75 years old; 3. Patients and their families signed informed consent. Exclusion criteria: 1. With chronic intestinal diseases and organ dysfunction; 2. With acute abdominal disease, intestinal obstruction, and electrolyte disturbance; 3. With other abdominal diseases like tumors or pelvic diseases; 4. With gastric diseases, bladder, and urinary tract diseases. There were 164 patients who met the criteria. All patients were randomly divided into a control group and an observation group according to random the number table method, 82 cases in each group. The approval has been obtained from the ethic committee of our hospital.

Methods

All the patients who received conventional enteral nutrition nursing strategy had an indwelling gastrointestinal or nasogastric tube. The front end of the nasogastric tube was required to insert 30 cm under pylorus distal or gastrointestinal anastomotic stoma. The control group adopted conventional gastric residual monitoring additionally. After surgery, patients were treated with enteral nutrition treatment for 6 hours. Drip 1 to 2 drops of 5% glucose ringer's solution at the front end of the nasogastric tube. The enteral nutrition liquid's original speed was 20 ml/h, and it kept dripping for 2~5 h. If the peristaltic condition was good, then the eating speed was adjusted to 80 mL/h. Measure gastric residual every 6 hours and make some adjustment as the following: gastric residual < 200 mL, kept the original speed; gastric residual < 100 mL, raised the infusion speed; gastric residual > 200 mL, stopped or lowered the infusion speed. The observation group adopted intra-abdominal pressure monitoring. Pumped the nutrient solution through silicone rubber nasogastric tube with a constant speed for 24 hours and provided energy supplements at 20 Kcal (Kg/d) through parenteral routes. When intra-abdominal pressure was > 20 mmHg, stopped the enteral nutrition, found out why intra-abdominal pressure was raised, analyzed and solved it correspondingly. When intra-abdominal pressure was 16 to 20 mmHg, kept the current amount of enteral nutrition. When intra-abdominal pressure was ≤ 15 mmHg, raised the pumping speed of enteral nutrition to 20 ml until the target amount was reached. Indirect bladder pressure measurement was adopted to monitor the intra-abdominal pressure. The standard measurement method proposed by the World Society of Abdominal Compartment Syndrome in 2013 was adopted. Patients' intra-abdominal pressure was measured 3 days before and after enteral nutrition treatment, 3 times a day to get the average value. Then dynamic monitoring of intra-abdominal pressure was applied.

Observation indexes and criteria for the clinical efficacy

(1) Clinical efficacy. (2) The intra-abdominal pressure and intra-abdominal hypertension rate. (3) The APACHE-II scores. APACHE-II stood for Acute Physiology and Chronic Health Evaluation [6]. It was made of 17 variables in terms of acute physiology, age, and chronic health status, including body temperature, blood pressure, creatinine level, etc. The overall APACHE-II score consisted of three parts and 71 was the highest score (the higher the score, the severe the patient's condition). (4) Enteral nutrition's tolerance level of the two groups. (5) Analyze the correlation between intra-abdominal pressure monitoring and pati-

Table 1. Comparison of the general information between the two groups

Indexes	Observation group (n = 82)	Control group (n = 82)	t/χ^2	*P*
Gender			1.563	0.078
Male	43	42		
Female	39	40		
Age ($\bar{x}$ ± sd, year)	53.0±10.5	53.2±10.3	1.236	0.968
Operation mode			1.369	0.654
Gastric Perforation repair	15	16		
Appendicectomy	53	52		
Cholecystectomies	14	14		

Table 2. Comparison of the clinical efficacy between the two groups ($\bar{x}$ ± sd)

Groups	abdominal pain relief time (d)	adjusted enteral nutrition time (h)	hospitalization time (d)
Observation group (n = 82)	3.45±0.40	31.04±3.79	11.28±5.68
Control group (n = 82)	7.05±1.21	52.07±5.86	20.87±8.80
t	25.580	27.290	8.291
P	< 0.001	< 0.001	< 0.001

ents' early enteral nutrition intolerance after abdominal surgery. Evaluations were made based on patients' clinical gastrointestinal symptoms [7]. During the enteral nutrition treatment, vomiting, reflux, abdominal distension, diarrhea, or gastric residual volume > 250 ml after 6 h continuous drip were symptoms of intolerance. Patients that had one or more of these symptoms were considered as intolerant. Patients who had no signs of the above gastrointestinal intolerance symptoms after 3 days were considered as tolerant. (6) Analyze the ROC curve of early enteral nutrition intolerance predicted by the intra-abdominal pressure.

Statistical analysis

Statistical analysis was performed using the SPSS statistical software 22.0. The qualitative data were represented by [n (%)] and tested by χ^2 test. The quantitative data were represented by ($\bar{x}$ ± sd) and examined by t test. Spearman correlation analysis was used to compare the patients' tolerance level and intra-abdominal pressure level as well as the average value of intra-abdominal pressure 3 days before early enteral nutrition correlation analysis. *P < 0.05* was considered as statistically significant.

Results

Comparison of the general information between the two groups

There was no significant difference in general clinical data and information between the two groups (P > 0.05). See **Table 1**.

Comparison of the clinical efficacy between the two groups

The abdominal pain relief time, adjusted enteral nutrition time and hospitalization time of the observation group were less than those of the control group. The difference was statistically significant (P < 0.05). See **Table 2**.

Comparison of the intra-abdominal pressure and intra-abdominal hypertension rate between the two groups

The intra-abdominal pressure and intra-abdominal hypertension rate was comparable before treatment (P > 0.05) and all were significantly reduced after treatment in the two groups (P < 0.05). After treatment, the above items were significantly lower in the observation group (P < 0.05). See **Table 3**.

Comparison of the APACHE-II scores between the two groups

Before treatment, the difference of the APACHE-II scores between the two groups was not statistically significant (P > 0.05). After monitoring, the APACHE-II scores of the observation group were significantly lower than those of the control group (P < 0.05). See **Table 4**.

Evaluation and analysis of the enteral nutrition's tolerance level of the two groups

Compared with the control group, the incidence of intolerance, diarrhea, bowel sound, gastrointestinal bleeding, reflux/vomiting, and stopping enteral nutrition was significantly

Table 3. Comparison of the incidence of intra-abdominal pressure and intra-abdominal hypertension before and after treatment

Groups	Intra-abdominal pressure ($\bar{x}$ ± sd, mmHg)		Intra-abdominal hypertension	
	Before treatment	After treatment	Before treatment	After treatment
Observation group (n = 82)	18.87±2.53	12.05±1.56[a]	42 (51.21)	8 (9.75)[a]
Control group (n = 82)	18.90±2.55	16.42±1.74[a]	50 (60.97)	24 (29.26)[a]
t/χ^2	0.075	16.93	1.585	9.939
P	0.939	< 0.001	0.208	0.002

Note: 'a' stands for the comparison of the incidence of intra-abdominal pressure and intra-abdominal hypertension before and after treatment in the study group, the difference was statistically significant (P < 0.05).

Table 4. Comparison of the APACHE-II scores before and after monitoring ($\bar{x}$ ± sd)

Groups	Before monitoring	After monitoring
Observation group	33.87±4.56	13.56±3.64[a]
Control group	34.56±4.65	20.02±3.64[a]
χ^2	0.338	11.650
P	0.959	< 0.001

Note: 'a' stands for the comparison of nutrition indexes before and after Hb/ALB/PA/TF treatments, the difference was statistically significant (P < 0.05).

lower for the observation group (P < 0.05), as shown in **Table 5**.

The correlation analysis between intra-abdominal pressure monitoring and patients' early enteral nutrition intolerance after abdominal surgery

According to Pearson correlation analysis, intestinal sounds were negatively correlated with intra-abdominal pressure level and the average value of intra-abdominal pressure 3 days before early enteral nutrition (r = -0.398, -0.453, P < 0.05), the difference was statistically significant; Gastrointestinal bleeding has no correlation with intra-abdominal pressure level and the average value of intra-abdominal pressure 3 days before early enteral nutrition (P > 0.05); Enteral nutrition intolerance, diarrhea, reflux/vomiting, 24 h residual volume, whether to stop enteral nutrition were positively correlated with the level of intra-abdominal pressure and the average value of intra-abdominal pressure 3 days before early enteral nutrition (r = 0.756, 0.845, r = 0.345, 0.310, r = 0.215, 0.267, r = 0.301, 0.235, r = 0.320, 0.246, P < 0.05). The difference was statistically significant, as shown in **Table 6**.

Analysis of ROC curve of early enteral nutrition intolerance predicted by the intra-abdominal pressure

The baseline of intra-abdominal pressure level and the average value of intra-abdominal pressure 3 days before early enteral nutrition predicted by the area of ROC curve of early enteral nutrition intolerance curve were 0.784 and 0.797, respectively when the critical baseline value of intra-abdominal pressure level was 12.5 mmHg. The average crucial value of intra-abdominal pressure 3 days before early enteral nutrition was 11.15 mmHg, the sensitivity was 85.5% and 67.3%, and the specificity was 60% and 73.3%, respectively. See **Figure 1**.

Discussion

As the largest immune organs and digestive organs, gastrointestinal organs maintain the body's nutritional status and immune function [8]. In abdominal surgery, the normal tissues are incised during surgery, which blocks part of the control nerves, causes gastrointestinal hormone regulation disorders, and negatively influences patients' life quality [9]. Enteral nutrition is one of the most common nutritional interventions in clinical treatments [10]. However, most abdominal surgery patients will have enteral nutrition intolerance due to delayed gastrointestinal emptying, prolonged patients' hospitalization time, thus raising the case fatality rates [11]. Studies [12, 13] have proven that the change of intra-abdominal pressure level can reflect patients' intestinal functions and gastrointestinal mucosal barrier function injury, and help the medical staff understand patients' gastrointestinal intolerance. The gastrointestinal tract is the most sensitive organ when the intra-abdominal pressure rises [14, 15]. The rise of intra-abdominal pressure

Table 5. Evaluation and analysis of the enteral nutrition's tolerance level

Indexes	Observation group (n = 82)	Control group (n = 82)	χ^2	*P*
Tolerance level			4.241	0.039
Tolerant	18	30		
Intolerant	64	52		
Diarrhea			6.155	0.013
Yes	20	35		
No	62	47		
Bowel sound			10.064	0.002
Normal	65	46		
Reduce/disappear	17	36		
Gastrointestinal bleeding			3.976	0.046
Yes	21	33		
No	61	49		
Reflux/vomiting			4.411	0.036
Yes	24	37		
No	58	45		
24 h residual volume			6.272	0.012
< 1000 ml	63	48		
≥ 1000 ml	19	34		
Stopping enteral nutrition			4.711	0.030
Yes	20	33		
No	62	49		

will lead to decreased gastrointestinal blood perfusion. Enteral nutrition intolerance easily causes the stop of nutrition support, which is bad for patients' recovery.

The results of this research suggest that the time of abdominal pain relief, adjusted enteral nutrition, and hospitalization of the observation group were shorter than those of the control group, indicating that early enteral nutrition treatment under intra-abdominal pressure monitoring can improve patient' prognosis, shorten the adjusted enteral nutrition time and hospitalization time. The intra-abdominal pressure and intra-abdominal hypertension rate in the observation group after treatment were lower than the control group ($P < 0.05$). It indicates that the dynamic monitoring of intra-abdominal pressure during early enteral nutrition treatment can timely identify the increased abdominal pressure and provide corresponding treatment. This can prevent the abdominal pressure from increasing and provide patients with better early enteral nutrition treatment. The APACHE-II scores of the observation group after monitoring was lower than that of the control group ($P < 0.05$). APACHE-II can evaluate the severity of multiple diseases, the effects of medical treatment, and predict patients' prognosis, and it has been regarded as a clinically reliable, objective, and scientific evaluation index [16]. Clinical studies [17] have confirmed that, patients' gastrointestinal function is impaired after abdominal surgery, and most of the traumas are stress injuries. This is closely related to the severity of diseases. Hence, APACHE-II is relative to the gastrointestinal function to some extent, and it can be an effective method to guide the timing of nutrition treatment. The incidence of intolerance, diarrhea, bowel sound, gastrointestinal bleeding, reflux/vomiting, and stopping enteral nutrition was significantly lower for the observation group, proving the good clinical effects of intra-abdominal pressure monitoring on patients' early enteral nutrition treatment after abdominal surgery. It effectively lowered the occurrence of complications of enteral nutrition and raised the success incidence of early enteral nutrition treatment.

According to Pearson correlation analysis, intestinal sounds were negatively correlated with intra-abdominal pressure level and the average value of intra-abdominal pressure 3 days before early enteral nutrition. Enteral nutrition intolerance, diarrhea, reflux/vomiting, 24 h residual volume, and whether to stop enteral nutrition was positively correlated with the level of intra-abdominal pressure and the average value of intra-abdominal pressure 3 days before early enteral nutrition. After abdominal surgery, patients' intra-abdominal pressure was raised, gastrointestinal tract's blood flow was decreased, mesenteric veins with thinner walls were compressed, intestinal veins' blood flow was blocked, their gastrointestinal tracts had edema, intestinal function

Table 6. Correlation analysis of patients' tolerance level and intra-abdominal pressure level and the average value of intra-abdominal pressure 3 days before early enteral nutrition

Projects	The baseline level of intra-abdominal pressure		The average value of intra-abdominal pressure 3 days before early enteral nutrition	
	r	*P*	*r*	*P*
Enteral nutrition intolerance	0.756	< 0.001	0.845	< 0.001
Diarrhea	0.345	< 0.001	0.310	< 0.001
Bowel sound	-0.398	< 0.001	-0.453	< 0.001
Gastrointestinal bleeding	-0.128	> 0.05	-0.214	> 0.05
Reflux/vomiting	0.215	0.001	0.267	< 0.001
24 h residual volume	0.301	0.035	0.235	0.024
Whether to stop Enteral nutrition	0.320	< 0.001	0.246	< 0.001

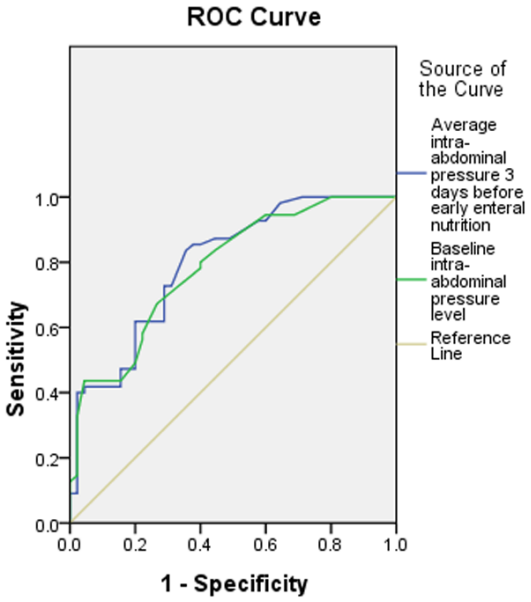

Figure 1. ROC cure analysis of FA predicted by IAP.

was declined, and gastrointestinal emptying was delayed. So, the occurrence of diarrhea, gastric residual volume, reflux/vomiting, and enteral nutrition intolerance increased during patients' enteral nutrition treatment [18, 19]. Due to the rise of intra-abdominal pressure, intestinal walls' blood vessels and intestinal tubes were compressed, leading to the ischemia of intestinal walls, gastrointestinal hypofunction, and peristalsis delay. Thus, intra-abdominal pressure is closely related to patients' enteral nutrition tolerance. Correlated domestic and overseas studies have shown that [20, 21], despite the diversity of research objects, there are correlations between intra-abdominal pressure level and the occurrence of diarrhea, reflux/vomiting, etc. during patient's enteral nutrition treatment. The ROC results indicated good clinical predictive effects of intra-abdominal pressure level on early enteral nutrition intolerance. Intra-abdominal pressure monitoring usually can reflect patients' gastrointestinal function. Intra-abdominal pressure level is a significant factor in terms of critical patients' enteral nutrition implementation. Studies have proven that [22] intra-abdominal pressure's baseline before early enteral nutrition can predict early enteral nutrition intolerance to some extent. Bejarano et al. [23] conducted a 53-months research on correlation between intra-abdominal pressure and enteral nutrition intolerance. The result indicated that the baseline of intra-abdominal pressure level has a predictive value on whether intra-abdominal hypertension happens or not when patients have enteral nutrition intolerance. However, the timing of providing enteral nutrition has not yet been discussed and determined.

Intraperitoneal pressure monitoring can significantly improve patients' symptoms, and it should be accurately measured for doctors to make timely diagnoses and provide proper treatments. This research is a case-control study based in a hospital; the number of cases collected was relatively small, and there were certain limitations. Follow-up studies should increase the case numbers and sources to figure out the predictive value of patients' early enteral nutrition intolerance after abdominal surgery predicted by the baseline of intra-abdominal pressure level.

Disclosure of conflict of interest

None.

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