Effects of blood glucose, blood lipids and blood pressure control on recovery of patients with gastric cancer complicated with metabolic syndrome after radical gastrectomy

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Abstract. This study aimed to investigate the effects of blood glucose, blood lipids and blood pressure control on recovery of patients with gastric cancer complicated with metabolic syndrome (MS) after radical gastrectomy. A total of 150 patients with gastric cancer, who were treated in Daqing Longnan Hospital from November, 2015 to May, 2017, were enrolled in this study. The patients were divided into the MS group (80 cases) and non-MS group (70 cases). Patients in the MS group were given corresponding drugs to control blood pressure, blood lipids and blood glucose, while patients in the non-MS group were not treated with those drugs. Patients in the MS group were divided into the normal and abnormal groups according to the levels of blood glucose, blood lipids and blood pressure. Moreover, occurrences of complications were compared between the normal and abnormal groups. Before surgery, blood glucose, blood lipids and blood pressure in the MS group were significantly higher than those in the non-MS group (p<0.05). One month after operation, blood glucose, blood lipids and blood pressure of the MS group decreased significantly compared to those before operation (p<0.05). Incidence of complications at 1 and 3 months after operation was significantly lower in the normal groups than that in the corresponding abnormal groups (p<0.05). Postoperative recovery was significantly better in the normal groups than that in the corresponding abnormal groups (p<0.05). Logistic regression analysis showed that the incidence of postoperative complications was related to fasting blood glucose, 2 h postprandial blood glucose, glycosylated hemoglobin, total triglycerides (TGs), LDL, mean blood pressure and BMI (p<0.05). The results show that, control of blood glucose, blood lipids and blood pressure in patients with gastric cancer complicated with MS after radical gastrectomy can reduce the incidence of postoperative complications and promote postoperative recovery.

Introduction

Gastric cancer is one of the most common malignant tumors of the digestive system, and the incidence of this disease ranks second among all types of cancer worldwide. Approximately 600,000 new cases are affected by gastric cancer every year worldwide, and 66% of these patients lose their lives due to this disease. The incidence of gastric cancer is two-fold higher in men than in women (1). Epidemiological studies have confirmed that gastric cancer occurs mainly in developing countries, such as China. Gastric cancer is a serious threat to human health. Therefore, in-depth studies on the mechanism of the occurrence and development of gastric cancer, as well as early detection and prevention, are extremely important for the treatment of patients with this disease (2). Related studies have shown that etiology of gastric cancer may be associated with environmental and dietary factors, and is also closely associated with *Helicobacter pylori* infection (3).

With the increased incidence of gastric cancer, effects of the disease-associated metabolic syndrome (MS) on the prognosis of patients with gastric cancer have been increasing. MS is a kind of syndrome with the main manifestations of central obesity, insulin resistance (IR), hypertension, high levels of triglycerides (TGs) and LDL-C, impaired glucose tolerance (IGT) and type 2 diabetes mellitus (T2DM) (4). Bloomgarden *et al* (5) showed that 70-80 million individuals in the United States are suffering from MS, accounting for 1/3 of the total population of that country. In China, the incidence of MS is 12.25% in the southern area (6) and 11.6% in the northern area (7,8), which were both lower than that in the United States, possibly due to the healthy Chinese diet and low incidence of obesity. With the changes in lifestyle, the incidence of gastric cancer has shown an increasing tendency, and gastric cancer is one of the major current health issues.

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Radical gastrectomy is currently recognized as the only way to cure gastric cancer. However, clinical application of radical gastrectomy is still challenged by the two classes of complications. The first class includes surgery-related complications, including postoperative bleeding, incision infection, incision split, lymphatic leakage, pancreatic fistula, anastomotic fistula, duodenal stump fistula, abdominal abscess, gastroparesis and intestinal obstruction. The other class includes postoperative complications, such as pneumonia, pleural effusion, cardiovascular accidents, pulmonary infarction and urinary tract infections, among which anastomotic fistula, pancreatic fistula, abdominal abscess and pneumonia are often referred to as the four major complications associated with radical gastrectomy (9).

The purpose of this study was to investigate the effects of blood glucose, blood lipid and blood pressure control on the occurrence of complications and postoperative recovery after radical gastrectomy in patients with gastric cancer complicated with MS.

Materials and methods

General information. A total of 150 patients with gastric cancer who were treated at the Daqing Longnan Hospital (Daqing, China) from November, 2015 to May, 2017 were enrolled in this study. Patients were divided into the MS and non-MS groups according to the presence of MS. The non-MS group included 70 patients, of whom 33 were females and 37 were males, and the mean age was 61.3±12.1 years. The MS group included 80 patients, of whom 39 were females and 41 were males, and the mean age was 62.4±10.4 years (Table I). There was no significant difference between the two groups regarding parameters such as age, sex, course of disease, BMI and other factors (Table I, p>0.05). Patients in the MS group were divided into the normal and abnormal groups according to the levels of blood glucose, blood lipids and blood pressure. All normal groups were referred to as group A, and abnormal groups were referred to as group B. Different types of radical gastrectomy were performed for different patients according to their conditions. Inclusion criteria were: All enrolled patients were diagnosed with gastric cancer by gastroscopy and biopsy before surgery, and MS was diagnosed according to the diagnostic criteria of MS proposed by the Chinese Medical Association Diabetes Branch (10).

Patients who met three or all of the criteria of the following four items were diagnosed as MS: i) Overweight and (or) obesity BMI≥25.0; ii) hyperglycemia: FDG≥6.1 mmol/l and (or) 2 hPG≥7.8 mmol/l and (or) patients diagnosed with diabetes and received treatment; iii) hypertension: SBP/DBP≥140 and (or) has been diagnosed with hypertension and received treatment; and iv) dyslipidemia: Fasting blood TG≥1.7 mmol/l. Exclusion criteria were: Severe cardiovascular and cerebrovascular diseases, renal failure, digestive system inflammation and mental disorders. This study was approved by the Ethics Committee of Daqing Longnan Hospital and all patients signed informed consent.

Research methods. Patients in the MS group were given corresponding drugs to control blood pressure, blood lipids and blood glucose, while patients in non-MS group were not
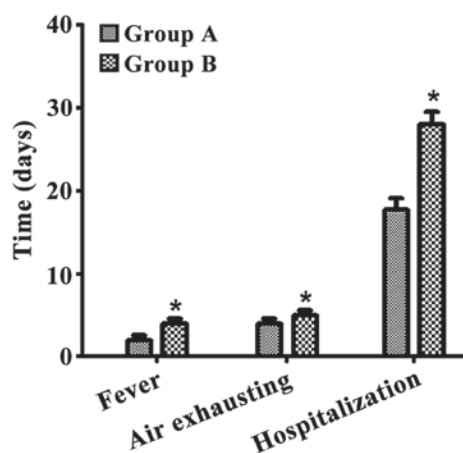

Figure 1. Comparison of durations of fever, air exhausting and hospitalization between the two groups. Durations of fever, air exhausting and hospitalization were significantly shorter in group A than in group B (*p<0.05).

treated with those drugs. Blood glucose, blood lipids, blood pressure, BMI, postoperative complications and recovery conditions of the two groups were recorded at 1 day before operation, and 1 and 3 months after operation.

Control standards. Patients in the MS group were treated with medication to control blood sugar, blood lipids and blood pressure after surgery. Specific requirements were as follows:

Postoperative blood glucose was controlled according to the recommended standards of the American Diabetes Association (2009) (11): i) FBG≤7.0 mmol/l, 2 hPG≤10 mmol/l, HbAlc ≤6.5%; and ii) FBG or 2hPG decrease >1.39 mmol/l or HbAlc decrease >1%.

Postoperative blood glucose control: Outcomes met at least one of the three criteria referred to as effective blood glucose control: i) TGs, total cholesterol and LDL decreased by >30%; ii) high-density lipoprotein (HDL) increased by >30%; and iii) blood lipids reached below-normal levels.

Postoperative blood pressure control: Outcomes met at least one of the three criteria referred to as effective blood pressure control: SBP or DBP dropped by >10 mmHg (1 mmHg=0.133 kPa) or reached below normal (140/90 mmHg) levels.

Statistical analysis. SPSS 17.0 statistical software (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Measurement data were expressed as mean ± SD, and paired t-test was used for comparisons within the two groups. In addition, count data were expressed as percentage and comparisons were performed by the χ^2 test. Finally, logistic regression analysis was performed to analyze the correlations between postoperative complications and blood glucose, blood lipids and blood pressure. P<0.05 was considered to be statistically significant.

Results

Comparison of blood glucose, blood lipids and blood pressure between the MS and non-MS groups before and at 1 month after surgery. Blood glucose, blood lipids and blood pressure

Table I. General information of the MS and non-MS groups.

Groups	Cases	Age (years)	Sex ratio (male/female)	Course of disease (months)	BMI (kg/m^2)
MS group	80	62.4±10.4	1.12	11.9±2.4	24.2±4.3
Non-MS group	70	61.3±12.1	1.05	11.4±2.1	24.7±5.1
P-value		0.521	0.143	0.243	0.211

MS, metabolic syndrome.

Table II. Comparison of blood glucose, blood lipids and blood pressure between the MS and non-MS groups before and at 1 month after surgery mean ± SD.

Items	MS group		Non-MS group	
	Before treatment	1 month after treatment	Before treatment	1 month after treatment
Blood glucose (mmol/l)	11.32±3.21	8.1±3.5[a]	7.2±2.5[b]	7.8±3.1
SBP	151.3±9.7	132.5±8.9[a]	128.9±10.4[b]	130.4±9.4
DBP	98.5±8.7	89.32±9.5[a]	85.5±8.6[b]	89.43±7.4
BMI (kg/m^2)	24.2±4.3	20.16±1.22[a]	24.7±5.1	23.15±1.06
Total TGs (mmol/l)	2.85±1.05	1.92±0.65[a]	1.70±1.25[b]	1.81±0.55
Total cholesterol (mmol/l)	5.51±1.65	3.82±1.42[a]	3.01±1.45[b]	3.32±1.23

[a]Comparisons within the two groups, p<0.05; [b]comparisons between the two groups at the same time-point, p<0.05. MS, metabolic syndrome; TGs, triglycerides.

Table III. Effects of blood glucose, blood lipids and blood pressure control on the occurrence of postoperative complications at 3 months after surgery (n, %).

Variables	Blood pressure		Blood glucose		Blood lipids	
	Normal (n=51)	Abnormal (n=29)	Normal (n=48)	Abnormal (n=32)	Normal (n=53)	Abnormal (n=27)
Incision infection	1	0	2	2	1	1
Incision rupture	0	2	1	2	0	3
Abdominal infection	0	2	0	2	0	1
Lung infection	0	1	1	2	0	1
Anastomotic fistula	1	3	0	2	1	2
Pancreatic fistula	1	3	0	0	1	1
Delayed emptying	1	1	0	1	0	0
Deep vein thrombosis	1	2	1	2	1	1
Total incidence	5 (9.8)	14 (48.3)	5 (10.4)	13 (40.6)	4 (7.5)	10 (37)
χ^2	35.958		24.004		25.153	
P-value	<0.001		<0.001		<0.001	

levels were significantly higher in the MS group than in the non-MS group before and at 1 month after surgery (p<0.05). Compared to pre-treatment levels, blood glucose, blood lipids and blood pressure in the MS group dropped significantly at 1 month after surgery (p<0.05) (Table II).

Effects of blood glucose, blood lipids and blood pressure control on the occurrence of postoperative complications at 3 months

after surgery. Incidence of postoperative complications in patients with normal blood glucose, blood lipids and blood pressure in the MS group was significantly lower than that in patients with abnormal blood glucose, blood lipids and blood pressure (Table III).

Comparison of postoperative recovery between the normal groups (group A) and corresponding abnormal groups

Table IV. Comparison of postoperative complications between groups A and B at 1 and 3 months after surgery (n, %).

	1 month after surgery		3 months after surgery	
Complications	Group A (n=22)	Group B (n=58)	Group A (n=22)	Group B (n=58)
Intestinal obstruction	1 (4.5)	3 (5.2)	2 (9)	5 (8.6)
Ascites	1 (4.5)	3 (5.2)	2 (9)	4 (6.8)
Pleural effusion	0 (0)	2 (3.4)	1 (4.5)	2 (3.4)
Anastomotic fistula	1 (4.5)	4 (6.8)	1 (4.5)	4 (6.8)
Incision infection	0 (0)	3 (5.2)	0 (0)	5 (8.6)
Incision rupture	0 (0)	3 (5.2)	0 (0)	5 (8.6)
Total incidence	3 (13.6)	18 (31)	6 (27.3)	25 (43.1)
χ^2	8.737		5.472	
P-value	0.003		0.019	

Table V. Value assignment of blood glucose, blood lipids, blood pressure and other related factors.

Serial no.	Items	Value assignment
1	FBG	≥0; male, 1
2	2 h postprandial blood glucose	<7.8 mmol/l, 0; ≥7.8 mmol/l, 1
3	Glycated hemoglobin	<6.1, 0; ≥6.1, 1
4	Total TGs	<1.7 mmol/l, 0; ≥1.7 mmol/l, 1
5	LDL	>0.9 mmol/l, 0; ≤0.9 mmol/l, 1
6	Average blood pressure	SBP/DBP<140/90 mmHg, 0; SBP/DBP≥140/90 mmHg, 1
7	BMI	<25, 0; ≥25, 1

TGs, triglycerides.

Table VI. Correlations between the postoperative complications and blood glucose, blood lipids and blood pressure by logistic regression analysis.

Observation indexes	Partial regression coefficient	Partial regression coefficient standard error	Wald χ^2 value	P-value	OR (95% CI)
Fasting blood sugar	1.344	0.336	15.977	<0.001	3.834 (1.984-7.411)
2 h postprandial blood glucose	0.783	0.443	8.126	0.037	2.189 (6.918-10.215)
Glycated hemoglobin	0.644	0.336	3.906	0.048	1.942 (1.006-3.752)
Total TGs	0.468	0.274	2.916	0.088	1.596 (0.93-2.730)
HDL	0.436	0.327	7.223	0.040	1.515 (6.814-8.941)
Average blood pressure	0.345	0.127	9.306	0.035	1.485 (7.912-12.540)
BMI	0.012	0.007	3.943	0.045	1.358 (1.065-1.650)

TGs, triglycerides; HDL, high-density lipoprotein.

(group B). The incidence of postoperative complications was significantly lower in group A than in group B (p<0.05; Table IV). Furthermore, postoperative recovery was significantly better in group A than in the corresponding group B (p<0.05, Fig. 1).

Correlations between postoperative complications and blood glucose, blood lipids and blood pressure by logistic regression analysis. Logistic regression analysis showed that the incidence of postoperative complications was associated with fasting blood glucose, 2 h postprandial blood glucose,

glycosylated hemoglobin, LDL, mean blood pressure and BMI (p<0.05) (Tables V and VI).

Discussion

The incidence and mortality rate of gastric cancer are relatively high in China. The mortality rate of gastric cancer is affected by regional factors and sex, and is higher in males than in females (12). The cure rate of gastric cancer at an early stage is relatively high, but most patients with gastric cancer are diagnosed at advanced stages due to lack of manifestations at early stages (13). MS is a group of metabolic disorders characterized by IR, including obesity, hyperglycemia, hypertension and dyslipidemia (14). Reynolds and He (15) reported that the incidence of MS was 19.5% in adults and 18% in women. MS is closely associated with the occurrence and development of various malignant tumors, especially gastrointestinal tumors, most commonly colorectal, liver and gastric cancer. In addition, Corley *et al* (16) have shown that diabetes is a risk factor for gastric cancer. Metabolic abnormalities can promote the occurrence and development of cancer, and dyslipidemia is closely associated with the occurrence of gastric cancer (17). The 5-year survival rate of cancer patients complicated with MS who underwent blood pressure and blood glucose control was significantly higher than that of those without proper blood pressure and blood glucose control (18). This study showed that the proper use of drugs for 1 month led to a decrease of blood pressure, blood lipids and blood glucose control to normal levels in the MS group, and there was no statistical difference between the MS and non-MS groups. In addition, the incidence of postoperative complications was significantly lower, while recovery conditions were significantly better in patients with normal blood pressure, blood lipids and blood glucose than that of patients with abnormal blood pressure, blood lipids and blood glucose at 1 and 3 months after surgery.

Wang *et al* (19) have shown that preoperative correction and improvement of certain medical factors in patients can reduce the incidence of complications to some extent. A body's stress response caused by surgical stimulation can cause IR in patients, which in turn affects the level of insulin and cause fluctuations of blood glucose, resulting in the occurrence of related complications. For MS patients, blood glucose, blood lipids and blood pressure should be controlled by using corresponding drugs after surgery to improve dyslipidemia. Compared with other risk factors, MS and its related factors have less controllability and are prone to fluctuate during the perioperative period, making them more prominent in occurrence of postoperative complications of gastric cancer patients. In this study, logistic regression analysis showed that incidence of postoperative complications was related to fasting blood glucose, 2 h postprandial blood glucose, glycosylated hemoglobin, total TGs, LDL, mean blood pressure and BMI (p<0.05). These findings are consistent with those reported by Kim *et al* (20) that patients with hyperglycemia, hypertension, and hyperlipidemia had a significantly higher probability of developing adverse reactions than non-MS patients, and BMI was in direct proportion to the incidence of hyperlipidemia.

In conclusion, effective control of blood glucose, blood lipid and blood pressure in patients with gastric cancer complicated with MS after radical gastrectomy can reduce the incidence of postoperative complications and promote postoperative recovery.

Availability of data and materials

The datasets used and/or analyzed during the present study are available from the corresponding author on reasonable request.

Authors' contributions

LS was a major contributor in writing this manuscript and patient treatment. PZ collected the data. QH analysed the data. CJ provided ideas on methods and interpreted the results. CG designed this study and performed the research. BS revised and finalized this report. All authors read and approved the final manuscript.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Daqing Longnan Hospital (Daqing, China). The patients who participated in this study, signed informed consent and had complete clinical data.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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