ELSEVIER

Surgery for Obesity and Related Diseases ▮ (2017) 00–00

SURGERY FOR OBESITY AND RELATED DISEASES

Original article

Impact of preoperative visceral fat proportion on type 2 diabetes in patients with low body mass index after gastrectomy

Min Jeong Park, M.D.[a], Dong Hyeok Kim, M.D.[a], Beom Jin Park, M.D., Ph.D.[b], Sungeun Kim, M.D.[c], Sungsoo Park, M.D., Ph.D., FASMBS[a,*], Raul J. Rosenthal, M.D., FACS, FASMBS[d]

[a]*Center for Obesity and Metabolic Diseases, Division of Upper Gastrointestinal Surgery, Department of Surgery, Korea University Anam Hospital, Korea University College of Medicine, Seoul, Korea*

[b]*Department of Radiology, Korea University Anam Hospital, Korea University College of Medicine, Seoul, Korea*

[c]*Department of Nuclear Medicine, Korea University Anam Hospital, Korea University College of Medicine, Seoul, Korea*

[d]*Bariatric and Metabolic Institute, Section of Minimally Invasive Surgery, Cleveland Clinic Florida, Weston, Florida*

Received March 2, 2017; accepted May 10, 2017

Abstract

Background: Metabolic surgery is an effective option for treatment of type 2 diabetes. Although body mass index (BMI) has several limitations in differentiating the metabolic risks of the same weight of muscle and fat, it is used as the basis of indication for metabolic surgery.

Objectives: Since visceral fat is highly associated with metabolic disease, we evaluated the effectiveness of visceral fat proportion (VFP) for predicting metabolic risk preoperatively.

Setting: University hospital.

Methods: Fifty-two type 2 diabetes patients with BMI $\leq$35 kg/cm^2 who underwent gastrectomy for gastric cancer were included. Pre- and postoperative VFPs were measured using abdominal computed tomography. Multivariate logistic regression analysis was performed to estimate the effect of VFP on type 2 diabetes. Receiver operating curve analysis was used to estimate the effectiveness of VFP as a predictor of type 2 diabetes improvement.

Results: Thirty-three of the 52 patients (63%) showed improved type 2 diabetes postoperatively. Low preoperative VFP (odds ratio [OR] = .913; 95% confidence interval [CI] = .835–.999; P = .048) and low glycated hemoglobin level (OR = .357; 95% CI = .172–.742; P = .006) were associated with type 2 diabetes improvement 2 years after gastrectomy. The area under the curve was 70.2%, indicating moderate accuracy.

Conclusions: Preoperative VFP might be a reasonable predictive factor for type 2 diabetes improvement after gastrectomy for patients with a BMI $\leq$35 kg/cm^2. High-quality studies of visceral fat for metabolic function are needed in the future. (Surg Obes Relat Dis 2017;▮:00–00.)

Keywords: Type 2 diabetes; Intra-abdominal fat; Gastrectomy; Computed tomography

Introduction

Metabolic surgery is considered a more effective treatment option than medical treatment for morbidly obese type 2 diabetes patients [1,2]. Roux-en-Y gastric bypass (RYGB) leads to a variety of metabolic effects beyond weight reduction, including type 2 diabetes remission [3–8]. The indication for metabolic surgery is currently based on body

This work was supported by the Industrial Strategic Technology Development Program (10051331) funded by the Korea Ministry of Trade, Industry and Energy, and by a Korea University grant.

Min Jeong Park and Dong Hyeok Kim contributed equally to this work.

*Correspondence: Sungsoo Park, M.D., Ph.D., Center for Obesity and Metabolic Diseases, Division of Upper Gastrointestinal Surgery, Department of Surgery, Korea University, Seoul, Korea.

E-mail: kugspss@korea.ac.kr

http://dx.doi.org/10.1016/j.soard.2017.05.012

mass index (BMI) as follows: BMI >40 kg/m^2, or >35 kg/m^2 along with co-morbidities such as type 2 diabetes, degenerative joint disease, or sleep apnea [9].

Ectopic fat, especially visceral fat, accounts for the highest proportion of all fats, and its role in metabolic diseases has been recently highlighted; furthermore, evidence of its significance independent of weight or BMI is increasing [10–12]. Patients with a large amount of visceral fat have impaired glucose metabolism more often than those with accumulated subcutaneous fat [13,14]. Moreover, even nonobese patients who have high visceral fat accumulation have impaired glucose metabolism [1].

BMI historically represents body shape and has been adopted as a simple tool to measure obesity. However, controversy over its limitations has raised doubts about its clinical usefulness [15]. BMI cannot distinguish between subcutaneous fat and visceral fat, which have different metabolic risks [16]. In addition, it cannot differentiate between lean muscle mass and adipose tissue of the same weight [17]. Furthermore, Asians have a greater metabolic risk for type 2 diabetes than Caucasians, although the former are in the normal BMI range [18]. Evaluation of obesity based only on BMI might result in misinterpretation of the metabolic risk for people with normal or low BMI, and could exclude patients who might benefit from obesity treatment. A recent study reported that type 2 diabetes patients with BMI <35 kg/m^2 who underwent metabolic surgery showed significant diabetes remission after surgery beyond weight reduction [19,20]. These findings highlight the need for complementary tools to predict the incidence of metabolic disease and indicate appropriate patients for metabolic surgery, especially individuals with normal or low BMI.

The purpose of this study was to elucidate the role of the quantity of visceral fat in the occurrence and improvement of metabolic syndrome by objectively measuring visceral fat and subcutaneous fat pre- and postoperatively using computed tomography (CT).

Materials and methods

Study population

We prospectively collected data from type 2 diabetes patients who underwent curative gastrectomy for stomach cancer at the Korea University Anam Hospital between January 2008 and November 2011. Nonmorbidly obese (BMI ≤ 35 kg/m^2) patients were included to exclude the effect of weight loss on diabetes improvement. Patients who experienced any complications related to gastrectomy were excluded [21]. In addition, patients with recurrent cancer or metastasis during the follow-up period for diabetes evaluation were excluded. The possible effects of adjuvant chemotherapy treatment and cancer stage in gastric cancer patients were adjusted using statistical methods. A total of 52 patients were included in the study. Patients with type 2 diabetes were assigned to 1 of 2 groups: the group that showed improvement and the group that did not show improvement over the 2-year postoperative evaluation period [22]. The improved group was further divided into 3 subgroups: partial remission, complete remission, and change in diabetes status. American Diabetes Association (ADA) criteria were used to diagnose diabetes [23], and the seventh edition of the American Joint Committee on Cancer staging manual was used to stage the gastric cancer [24]. The ADA consensus was also used to define partial remission as subdiabetic hyperglycemia for at least 1 year in the absence of active pharmacologic therapy or ongoing procedures, and subdiabetic hyperglycemia as a fasting blood glucose level of 100–125 mg/dL (5.6–6.9 mmol/L) and glycated hemoglobin (HbA1C) level $<6.5\%$ [25]. Complete remission was used as a normal measure of glucose metabolism for at least 1 year in the absence of active pharmacologic therapy or ongoing procedures. Normal measures of glucose metabolism were fasting glucose <100 mg/dL (5.6 mmol/L) and HbA1C level in the normal range [19]. A change in diabetes status was defined as significant improvement (>25 mg/dL) in the fasting plasma glucose level or significant reduction of 1% in the HbA1C level, or significant reduction in the diabetes medication or dose (by discontinuing one agent or one-half reduction in dose) [26]. Since the data used were routinely collected, informed consent was not specifically obtained. The study was approved by the Institutional Review Board of the Korea University Anam Hospital.

Operative method

Radical stomach resection was performed for stomach cancer. All patients received at least omentectomy and D1+α lymph node dissection. Total gastrectomy was performed with RYGB anastomosis. The Roux limb and afferent limb of the anastomosis were 50 cm and 20 cm, respectively. Subtotal gastrectomy was performed with Billroth I or Billroth II anastomosis. The stomach was resected 75% in subtotal gastrectomy, and the afferent limb was 15–20 cm in Billroth II anastomosis. Vagotomy was routinely performed during lymph node dissection.

Measurement of fat profile

Preoperative and 2-year postoperative abdominal CT scan data were used for measurement of the patients' fat profile. Fat analysis was performed using Aquarius® iNtuition™ software (TeraRecon, Foster City, CA, USA) at the level of the umbilicus, which reflects the whole body's fat profile [27]. A standard reference of –190 to –30 Hounsfield units (HUs) designated the fat area [28,29]. Subcutaneous fat tissue was defined by outlining its contour. Pixels with a mean ± 2 SD HU of fat tissue were