Negative Correlation Between Body Mass Index and Chest Tube Out-put After Coronary Artery Bypass Graft Surgery

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ABSTRACT

Introduction: The obvious threat of obesity to human life is well-known, but some contradictory outcomes have been encountered during previous medical research. Interestingly, obesity was recognized as a protective factor for some specific obesity-related situations. We aimed to correlate increased body mass index (BMI) and chest tube out-put after coronary artery bypass grafting (CABG).

Patients and Methods: We retrospectively collected data of 421 patients who underwent isolated CABG surgery between dates of December 2015 and December 2016. Obtained BMI values were grouped into: underweight (< 20 kg/m^2), normal weight (20-25 kg/m^2), overweight (25-30 kg/m^2), obese (30-35 kg/m^2), and severely obese (> 35 kg/m^2) subclasses. The postoperative chest tube output volume corresponded drainage at first 24 hours after the CABG surgery.

Results: The mean age was 61.6 (± 1.06) years. Female to male ratio was found 40, 9/59, 6 (n= 170/251). The patient population was divided into 2 groups as BMI below and above 30 kg/m^2 to approximately evaluate the relation between BMI and chest tube out-put. Overall, 193 patients were in the non-obese group, and 136 patients were in the obese group. The mean drainage amounts of non-obese and obese groups were 630 ± 360 and 463 ± 303 mL, respectively. We ran independent t-test to evaluate the relationship between BMI and chest tube out-put. It was statistically significant. The relationship between drainage and five different BMI subgroups was evaluated. Analysis of variance (ANOVA) showed statistically significant chest tube output difference between the normal and obese groups as well as the severely obese group.

Conclusion: BMI is negatively correlated with bleeding after CABG surgery and should be considered in future bleeding prediction systems.

Key Words: Body mass index; obesity; bleeding; chest tube out-put; cardiac surgery; coronary artery bypass surgery

Beden Kitle İndeksi ile İzole Koroner Baypas Cerrahisi Sonrası Beklenen Göğüs Tüpü Drenajı Arasındaki Negatif Korelasyon

ÖZET

Giriş: Obezitenin insanlık için iyi bilinen bir tehdit unsuru olduğu kanıtlanmış bir gerçektir. Ancak yıllar içinde yapılan birtakım araştırmalarda obezitenin belirli durumlarda koruyucu rolü olduğu gibi çelişik durumlar gözlemlenmiştir. Bu çalışmada artmış beden kitle indeksi (BKİ) değerleri ile koroner arter baypas greftleme (KABG) cerrahisi sonrası göğüs tüpü drenajı arasındaki ilişkiyi ortaya koymayı amaçladık.

Hastalar ve Yöntem: Aralık 2015-Aralık 2016 tarihleri arasında, izole KABG operasyonu geçirmiş 421 hastanın verileri retrospektif olarak tarandı. BKİ değerleri, Amerikan Kalp Derneği ve Dünya Sağlık Örgütü tarafından belirlenen alt sınıflara gruplandırıldı. Bu alt gruplar; zayıf (< 20 kg/m^2), normal (20-25 kg/m^2), fazla kilolu (25-30 kg/m^2), obez (30-35 kg/m^2) ve morbid obez (> 35 kg/m^2) olarak kabul edildi. Postoperatif göğüs tüpü drenaj değeri KABG sonrası ilk 24 saatte ölçülen değer olarak kaydedildi.

Bulgular: Çalışmaya katılan ortalama hasta yaşı 61.6 ± 1.06 idi. Hasta popülasyonunun çoğunluğunu 251 (%59.6) hasta ile erkekler oluşturmaktaydı. Hastalar önce kabaca obez (> 30 kg/m^2) (n= 136) ve non-obez (< 30 kg/m^2) (n= 193) olmak üzere iki gruba ayrıldı. Obez olmayan grupta postoperatif ortalama göğüs tüpü drenaj miktarı 630 ± 360 mL iken, obez hasta grubunda 463 ± 303 mL bulundu. BKİ ile KABG sonrası göğüs tüpü drenajı arasındaki ilişkinin analizi için bağımsız t-test kullanıldı. Test sonucunda ortaya çıkan ilişki istatistiksel olarak anlamlı idi. Bunun üzerine ileri analiz amaçlı olarak KABG sonrası göğüs tüpü drenajının beş farklı BKİ alt grubu ile ilişkisini değerlendirmeye karar verdik. Bunun için varyans analizi (ANOVA) yapıldı ve sonuçların istatistiksel olarak anlamlı olduğu görüldü.

Sonuç: BKİ ile KABG sonrası göğüs tüpü drenajı arasında negatif bir korelasyon bulunmaktadır. BKİ'nin ileride planlanabilecek kanama öngörü skorlarında kullanılabileceğini düşünmekteyiz.

Anahtar Kelimeler: Beden kitle indeksi; obezite; kanama; drenaj; kardiyak cerrahi; koroner arter baypas

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INTRODUCTION

Obesity is an active global problem with an increasing incidence. The adverse events arising from the pathological nature of obesity are of immense concern among general medical and cardiac specialists. According to the American College of Cardiology/American Heart Association (ACC/AHA) report released in 2013, overweight and obese adults account for 69% of the entire US population[1]. An epidemiological study revealed that during the last 20 years, the prevalence of obesity is increased by 20% and affected 36% of the population in Turkey[2].

Although the obvious threat of obesity to human life is well-known, some contradictory outcomes were encountered during previous medical research. Obesity was recognized as a protective factor for specific obesity-related situations. However, the mechanisms behind these contradictory situations are not well understood, and recent studies have focused on the physiological, biochemical, and behavioral reasons.

However, obesity is commonly recognized as a risk factor for various morbidities after cardiac surgery, it is not a direct risk factor for mortality alone[3]. In our study, we aimed to show the relation between increased body mass index (BMI) and chest tube out-put after coronary artery bypass grafting (CABG).

PATIENTS and METHODS

Data of 421 patients who underwent isolated CABG surgery between December 2015-December 2016 were retrospectively collected after approval from the ethics committee. Patients with previously known coagulopathy were excluded. Emergency operations were excluded due to lack of data. Re-operations were excluded due to increased bleeding and increased need for blood transfusion rates, as shown previously[4]. Additionally, we excluded off-pump CABG cases to avoid cardiopulmonary bypass-related factors, such as hemodilution, foreign surface exposure, mechanical blood cell damage and temperature changes, which may affect blood loss[5].

BMI was calculated by dividing the individual patient's weight in kilograms by the height in meters squared. The obtained BMI values were grouped into classes, determined by the AHA and the World Health Organization[1]. These classes were defined as underweight (< 20 kg/m^2), normal weight (20-25 kg/m^2), overweight (25-30 kg/m^2), obese (30-35 kg/m^2), and severely obese (> 35 kg/m^2).

The postoperative chest tube out-put volume corresponded to drainage at the first 24 hours after the CABG surgery. The postoperative chest tube out-put was recorded in milliliters. Even though most of the patients have had more than one chest tube, values were recorded as the total amount regardless of the site where chest tubes were placed.

Statistical Analysis

Microsoft Office, Microsoft Excel 2010™ was used to organize the study data, and the Statistical Package for Social Sciences (SPSS™) version 21 was used for all statistical analysis. In this study, the significance level was set at $p < 0.05$. An independent t-test was used to reveal the relation between BMI > 30 kg/m^2 groups and the amount of drainage. Spearman correlation analysis was performed to determine the strength and direction of this relationship. A one-way analysis of variance (ANOVA) test was used to evaluate the relationship between drainage and five different BMI subgroups.

RESULTS

The total number of patients was 421. The mean age was found 61.6 (± 1.06) years. Among the 421 patients, the youngest patient was 21 years old, and the oldest patient was 83 years old. The number of female patients was 170 (40.9%), and the number of male patients was 251 (59.6%); hence, men were predominant in the study. The co-existing morbidities recorded were Type 1 and 2 diabetes mellitus (46.1%, n= 194), chronic obstructive pulmonary disease (15%, n= 63), renal injury (calculated creatinine clearance, < 85 mL/min; 15.2%, n= 64), peripheral arterial disease (8.8%, n= 37), pulmonary hypertension (PAPs > 45 mmHg) (8.3%, n= 35), and neurological dysfunction (9.7%, n= 41). The mean ejection fraction of the patients was 55.3% ± 10.4; 76.5% patients were New York Heart Association (NYHA) Class 1 with no significant functional incapability; 14.5% were NYHA Class 2, 8.1% were NYHA Class 3, and only 1% was NYHA Class 4. The number of patients with acute myocardial infarctions (AMI) was 158 (37.5%), and 7.1% of the patients (n= 30) underwent surgery under unstable hemodynamic circumstances, such as the need for positive inotropic agents and/or need for intra-aortic balloon pump support. Preoperative variables are listed at Table 1.

The mean total perfusion duration was 80 ± 31 minutes, and the mean cross-clamping duration was 59 ± 26 minutes. All the patients were transferred to the cardiac intensive care unit (ICU) with a mechanical ventilatory support. The mean mechanical ventilation duration was 14.5 ± 22.7 hours. The shortest mechanical ventilation duration was 5 hours, while the longest was 336 hours. The mean ICU stay was 2.9 ± 2.7 days. The mean hospital stay after surgery was 9.1 ± 5.1 days; 27 patients (6.4%) underwent resternotomy for bleeding. The early mortality rate after surgery (first 30 days) was 4.5% (n=19). The operative outcomes are listed in Table 2.

The patient population was divided into 2 groups as BMI below and above 30 kg/m^2 to approximately evaluate the relation between BMI and chest tube out-put; 193 patients were in BMI

Table 1. Preoperative variables

Variable	%	N
Age (years)	61.6 ± 10.6	
Female-Male	40.4-59.6	170-251
BMI	28.7 ± 4.9	
BMI subgroups		
< 20 kg/m^2	2.1	9
20-24.9 kg/m^2	20.2	85
25-29.9 kg/m^2	37.3	157
30-34.9 kg/m^2	30.2	127
> 35 kg/m^2	10.2	43
DM	46.1	194
COPD	15	63
Renal injury	15.2	64
PAD	8.8	37
PHT	8.3	35
Neurological dysfunction	9.7	41
AMI	37.5	158
Unstable hemodynamics*	7.1	30
EF	55.3 ± 10.4	
NYHA		
Class 1	76.5	322
Class 2	14.5	61
Class 3	8.1	34
Class 4	1	4

* Need for positive inotropic agents and/or intra-aortic balloon pump support.
BMI: Body mass index, DM: Diabetes mellitus, COPD: Chronic obstructive pulmonary disease, PAD: Peripheral arterial disease, PHT: Pulmonary hypertension, AMI: Acute myocardial infarction, EF: Ejection fraction, NYHA: New york heart association.

Table 2. Perioperative results

	Mean
Total chest tube out-put amount (mL)	567 ± 347
BMI subgroups	
< 20 kg/m^2	700 ± 358
20-24.9 kg/m^2	663 ± 420
25-29.9 kg/m^2	606 ± 323
30-34.9 kg/m^2	480 ± 328
> 35 kg/m^2	416 ± 208
CPB time (minutes)	80 ± 31.4
XCL time (minutes)	59 ± 26
Mortality (first 30 days)	4.5 (n= 19)
Resternotomy	6.4 (n= 27)
Mechanical ventilation duration (hours)	14.5 ± 22.7
ICU stay duration (days)	2.9 ± 2.7
Hospital stay after surgery (days)	9.1 ± 5.12

BMI: Body mass index, CPB: Cardiopulmonary bypass, XCL: Cross clamp, ICU: Intensive care unit.

< 30 kg/m^2 group (non-obese), and 136 patients were in BMI > 30 kg/m^2 group (obese). The mean drainage amounts of non-obese and obese groups were 630 ± 360 mL and 463 ± 303 mL, respectively. The variables were distributed equally, and an independent t-test was used to evaluate the relationship between BMI and chest tube out-put. The result was statistically significant (p= 0.001). The Spearman Rank Correlation test showed a 25.8% negative correlation between BMI and chest tube out-put, which means a high BMI is related to lower drainage. As other studies have highlighted, we evaluated the relationship between drainage and five different BMI subgroups(6,7). ANOVA showed that there was no statistically significant chest tube out-put difference between the underweight group and others. However, there was no statistically significant difference between the normal and overweight groups, we found a statistically significant chest tube out-put difference between normal and obese groups as well as the severely obese group. The mean chest tube output difference between the normal and obese groups was 183.77 mL (p= 0.05), while the mean difference between the normal and severely obese groups was 247.70 mL (p= 0.05). We also found statistically significant chest tube out-put difference between the overweight and obese groups as well as the severely obese group. The mean chest tube out-put difference between the overweight and obese groups was 126.15 mL (p= 0.049), while the mean difference between the overweight and severely obese groups was 189.92 mL (p= 0.031). No statistically significant chest tube out-put difference was found between obese and severely obese groups. Chest tube out-put differences between the BMI subgroups are listed in Table 3.

DISCUSSION

The increasing incidence of obesity and its negative outcomes were the prime considerations for conducting the present study. However, we always deal with the dark side of the obesity, at some points, it comes across as a protective factor, such as in our study. Clinicians and researchers commonly have a prejudiced opinion on obesity and obese individuals. Gruberg et al. put forth the phenomenon of "Obesity Paradox" for the first time in 2002(8). According to them, underweight and normal BMI patients experience adverse events much more frequently than the rest after coronary intervention(8). Thereafter, the Obesity Paradox terminology was acknowledged, which gave another aspect to researchers about obesity. Le Bert et al. mentioned Obesity Paradox in their study and highlighted the possible protective features of obesity(9). After a brief review of literature, we believe that obese patients should not be subjected to prejudgment

Table 3. Mean chest tube out-put volume differences between BMI subgroups

BMI subgroup (kg/m^2)	Comparison subgroup (kg/m^2)	Mean volume difference (mL)	p
< 20 (underweight)	20-24.9	36.02	0.999
	25-29.9	93.64	0.954
	30-34.9	219.80	0.459
	> 35	283.57	0.257
20-24.9 (normal)	< 20	-36.02	0.999
	25-29.9	57.61	0.797
	30-34.9	183.77	0.005
	> 35	247.54	0.005
25-29.9 (overweight)	< 20	-93.64	0.954
	20-24.9	-57.61	0.797
	30-34.9	126.15	0.049
	> 35	189.76	0.031
30-34.9 (obese)	< 20	-219.80	0.459
	20-24.9	-183.77	0.005
	25-29.9	-126.15	0.049
	> 35	63.76	0.873
> 35 (severely obese)	< 20	-283.57	0.257
	20-24.9	-247.54	0.005
	25-29.9	-189.76	0.031
	30-34.9	-63.76	0.873

BMI: Body mass index.

and negative discrimination at clinical practices and research but should be well understood and assessed.

The initial statistical analysis revealed a negative correlation between BMI and postoperative chest tube out-put in our study. This result supports both our hypothesis and recent literature regarding the subject. Through the present study, for one more time, it has been shown that BMI > 30 kg/m^2 is a protective factor considering postoperative bleeding after CABG. The secondary result showed that there is also a statistically significant difference between BMI subgroups and postoperative bleeding. Usually, the relation between BMI and outcomes after CABG was dichotomized even at some of the comprehensive studies[(10)]. We think that the sole analysis with dichotomous variables is inadequate and less detailed. The benefit of ordinal categorical analysis of BMI subgroups for evaluating the relation between BMI and bleeding was emphasized by Nolan et al.[(6)]. Therefore, we additionally performed a one-way ANOVA test between the BMI subgroups and achieved stronger and more satisfactory results, supporting our initial hypothesis.

The causes of obesity that bore contradictory outcomes in the cardiac surgery field have been discussed in previous studies. Researchers mainly focused on the physiologic, biochemical and even behavioral mechanisms. Gruberg et al. accused excessive anticoagulation at underweight patients to explain the negative correlation between BMI and postoperative bleeding[(8)]. Another study dwells upon the idea that obese patients are diagnosed at younger ages and evaluated thoroughly and receive better treatment due to the well-known risks of obesity[(9)]. The biochemical explanations of this subject are gathered around the procoagulant tendency of patients with obesity and metabolic syndrome[(11)]. As stated in a review study, in obese individuals, blood Plasminogen Activator Inhibitor 1 (PAI-1) levels are higher than in nonobese people. The most possible explanation is that PAI-1 molecule is synthesized by adipocytes, particularly located in the subcutaneous tissue[(12)]. However, many mechanisms were suggested, and there is no clear and certain explanation of this situation due to the complex physiological and molecular nature.

One of the most important concepts regarding obesity and postoperative bleeding is the heparin rebound, which challenges our study. Heparin rebound highlights the pharmacokinetic features of unfractioned heparin (UFH). The pharmacokinetics of UFH includes a peripheral process by which the UFH molecule is converted from the free to the bound state[(13)]. The adipose tissue is one of the peripheral compartments where UFH binds. We can hypothesize that the probability of heparin redistribution increases, as the adipose tissue mass distributed heparin increases. Yet, there is no strong evidence to prove the hypothesis, at least in the field of cardiac surgery. Recently, Aykut, et al. published an original article based on UFH dose calculation according to the estimated lean body weight, which represents body weight without body fat weight[14]. As a result of their study, there is no statistically significant difference between the actual body weight and lean body weight groups regarding bleeding after cardiac surgery. The complex pharmacological nature of UFH leaves us with contradictory and inconsistent outcomes until clarified by further studies.

Postoperative resternotomy and the need for blood transfusion are positively correlated with some adverse outcomes after cardiac surgery. These adverse outcomes are increased mortality; longer mechanical ventilation, ICU stay, hospital stay durations; and renal failure[15]. Researchers are trying to develop preoperative bleeding prediction scores to avoid these negative outcomes. WILL-BLEED, CRUSADE, and e-CABG registry bleeding scores are some of the examples. However, WILL-BLEED and CRUSADE scores acknowledged the negative correlation between bleeding and BMI. BMI is not accepted as a variable at these scoring systems because the analysis of the researchers failed in showing the prognostic importance of BMI in bleeding after coronary artery surgery[16]. The e-CABG Bleeding Severity Classification system included BMI as a dichotomous variable and defined as below or above 25 kg/m^2[17]. According to our study results, we believe that BMI could be used as an ordinal categorical variable with its predefined classes to achieve more accurate results.

The most obvious limitation of our study was its retrospective design, which caused most of the obstacles we encountered. During the data collection period, we found that some of the data were either missing or defective. We excluded those data and secondary variables and results from the study to maintain the reliability. A prospectively designed study can reveal much more accurate and detailed results by analyzing the complete and purposeful data.

CONCLUSION

In this study, we showed that BMI is negatively correlated with bleeding after a CABG surgery. This result may help surgeons in predicting bleeding after surgery in their daily practice. To increase the efficacy and validity of this concept, BMI should be included in future bleeding prediction systems. It is obvious that BMI calculation is an easily applicable method and provides convenient results to use in a bleeding Prediction system.

CONFLICT of INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

AUTHORSHIP CONTRIBUTIONS

Concept/Design: MA
Analysis/Interpretation: DG
Data Acquisition: EÇ
Writting: EÇ
Critical Revision: MA
Final Approval: All of authors.

REFERENCES

1. Apovian C, Aronne L. The 2013 American Heart Association/American College of Cardiology/The Obesity Society Guideline for the Management of Overweight and Obesity in Adults. Circulation 2015;132:1586-91.
2. Erem C. Prevalence of overweight and obesity in Turkey. IJC Metabolic&Endocrine 2015;8:38-41.
3. Costa V, Ferolla S, Reis T, Rabello R, Rocha E, Couto C, et al. Impact of body mass index on the outcome in patients undergoing coronary artery bypass grafting and or valve replacement surgery. Revista Brasileira de Cirurgia Cardiovascular, 2015.
4. Roselli E, Pettersson G, Blackstone E, Brizzio M, Houghtaling P, Hauck R, et al. Adverse events during reoperative cardiac surgery: Frequency, characterization, and rescue. The Journal of Thoracic and Cardiovascular Surgery 2008;135:316-23.e6.
5. Guru V, Fremes S. Impact of off-pump coronary artery bypass surgery on postoperative bleeding: Current best available evidence. Journal of Cardiac Surgery 2006;21:42-3.
6. Nolan H, Davenport D, Ramaiah C. BMI Is an independent preoperative predictor of intraoperative transfusion and postoperative chest-tube out-put. International Journal of Angiology 2013;22:031-06.
7. Reeves B, Ascione R, Chamberlain M, Angelini G. Effect of body mass index on early outcomes in patients undergoing coronary artery bypass surgery. ACC Current Journal Review 2003;12:63.
8. Gruberg L, Weissman N, Waksman R, Fuchs S, Deible R, Pinnow E, et al. The impact of obesity on the short-term andlong-term outcomes after percutaneous coronary intervention: the obesity paradox? Journal of the American College of Cardiology 2002;39:578-84.
9. Le-Bert G, Santana O, Pineda A, Zamora C, Lamas G, Lamelas J. The obesity paradox in elderly obese patients undergoing coronary artery bypass surgery. Interactive CardioVascular and Thoracic Surgery 2011;13:124-7.
10. Alam M, Siddiqui S, Lee V, Elayda M, Nambi V, Yang E, et al. Isolated coronary artery bypass grafting in obese individuals. Circulation Journal 2011;75:1378-85.
11. Wang M, Chen M, Ao H, Chen S, Wang Z. The effects of different BMI on blood loss and transfusions in chinese patients undergoing coronary artery bypass grafting. Annals of Thoracic and Cardiovascular Surgery 2017;23:83-90.
12. Mertens I, Gaal L. Obesity, haemostasis and the fibrinolytic system. Obesity Reviews 2002;3:85-101.
13. Jia Z, Tian G, Ren Y, Sun Z, Lu W, Hou X. Pharmacokinetic model of unfractionated heparin during and after cardiopulmonary bypass in cardiac surgery. Journal of Translational Medicine 2015;1-11.
14. Aykut A, Sabuncu Ü, Demir ZA, Balcı E, Soran Türkcan B, Ünal U, et al. Heparin dose calculated according to lean body weight during on-pump heart surgery. Turkish Journal of Thoracic and Cardiovascular Surgery 2018;26.
15. Vivacqua A, Koch C, Yousuf A, Nowicki E, Houghtaling P, Blackstone E, et al. Morbidity of bleeding after cardiac surgery: is it blood transfusion, reoperation for bleeding, or both? The Annals of Thoracic Surgery 2011;91:1780-90.
16. Brascia D, Onorati F, Reichart D, Perrotti A, Ruggieri V, Santarpino G, et al. Prediction of severe bleeding after coronary surgery: the WILL-BLEED Risk Score. Thrombosis and Haemostasis 2017;117:445-56.
17. Mariscalco G, Gherli R, Ahmed A, Zanobini M, Maselli D, Dalén M, et al. Validation of the european multicenter study on coronary artery bypass grafting (E-CABG) bleeding severity definition. The Annals of Thoracic Surgery 2016;101:1782-8.