RESEARCH ARTICLE

Effect of nutritional status on wound healing after coronary artery bypass graft (CABG) surgery

Muazama Zaffar,[1] Asma Afreen,[2] Muhammad Waseem,[3] Zaheer Ahmed[4]

Abstract

Objective: To assess the pre-operative nutritional status and its effect on wound healing of patients having undergone coronary artery bypass graft surgery.

Method: The hospital-based prospective study was conducted at the Armed Forces Institute of Cardiology/National Institute of Heart Disease, Rawalpindi, Pakistan, from October 2017 to March 2018, and comprised patients who underwent coronary artery bypass graft surgery. Sternal wound healing as an outcome measure was assessed with nutritional status. Investigation of dietary data focussed on various food groups and their impact on wound healing. Data was analysed using SPSS 21.

Results: Of the 330 patients, 16 (4.8%) died within hospital. The final sample, as such, comprised 314(95.2%) patients; 273 (86.9%) males and 42 (13.1%) females, with an overall mean age of 56.6±8.3 years. The mean body mass index was 26.9±4.3kg/m^2. There was non-significant relationship between body mass index and wound healing ($p>0.05$). Significant relationship was observed between albumin, blood glucose and wound healing ($p<0.05$).

Conclusion: Low levels of albumin and poor blood glucose control before surgery was found to be associated with delayed wound healing. Nutritional intervention prior to coronary artery bypass graft surgery may lead to reduced risk and complications during / after surgery.

Keywords: Coronary artery bypass graft surgery, Body mass index, Sternal wound infection, Nutritional status.
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Introduction

Cardiovascular diseases (CVDs) are the leading cause of morbidity and mortality all over the world. The World Health Organisation (WHO) estimates showed that during 2013 alone >17.3 million people died from CVDs which represents 31% of deaths globally.[1] Among them, 6.5 million deaths were due to stroke and 7.4 million were due to coronary artery diseases (CADs).[2] Coronary artery bypass graft (CABG) procedures are the proven therapies for the treatment of ischaemic heart diseases (IHDs) and about 200,000 CABG procedures are annually performed in the United States.[3] Percutaneous coronary intervention (PCI) is considered an urgent procedure for CADs, but CABG may still be needed for some patients to treat CADs.[4] Secondary prevention of CABG surgery, including diabetes mellitus (DM), hypertension (HTN), weight-loss and cardiac rehabilitation, plays an important role in the prevention of cardiac mortality and post-operative outcomes.[5]

Relationship of body size and CABG surgery has been an ongoing debate during the last decades. Body mass index (BMI) in most surgical procedures has been defined as the indicator of malnutrition. In cardiac surgery, patients with pre-operative reduced food intake, unintentional weight-loss and BMI >40 or <20 are at higher nutritional deficiency risk.[6] Gao, Sun[7] observed that obesity is positively associated with deep sternal wound infection (DSWI), need for dialysis, prolonged ventilation time, mortality and readmission. However, some studies also indicated that obesity or BMI >35 is considered to be a risk factor for CADs and obese patients requiring CABG surgery showed a strong association between BMI and morbidity post-surgery. The relationship of BMI and infectious complications is also not very clear. Some studies reported that high BMI had a risk for DSWI as well as vein harvest infection (VHI) after CABG surgery. This risk of infection with high BMI was due to higher DM occurrence and because of low oxygen supply at the wound site.[8]

Human serum albumin (HAS) is used to treat several diseases, such as hypovolaemia, surgical blood-loss, burns and shocks, cardiopulmonary bypass, respiratory distress syndrome (RDS), nutrition support and hypo-albuminaemia.[9] Several studies indicate low serum album as a strong predictor of mortality in different surgical procedures, including prostate, gynaecological and

[1]Pakistan Naval Hospital, PNS Hafeez, Naval Complex, Islamabad, [2,4]Department of Health and Nutritional Sciences, Research Complex, Allama Iqbal Open University, Islamabad, [3]Armed Forces Institute of Cardiology / National Institute of Heart Disease (AFIC/NIHD), Rawalpindi, Pakistan.
Correspondence: Asma Afreen. Email: asma.afreen@aiou.edu.pk

cardiac ones. This high rate of mortality is the relation of low albumin with inflammation, which activates response proteins that increases the permeability of vessels for protein and reduces the synthesis of protein in the liver.[10] It is clearly indicated that albumin levels <30g/L prior to surgery is an independent risk factor for sternal wound infection and mortality.[6] Likewise, pre-operative malnutrition is also a risk factor for both wound infection and mortality.[11] Considering malnutrition as a co-morbid factor for post-operative outcomes, nutritional assessment and provision of dietary counselling plays an important role in overcoming malnutrition. In line with literature,[12] the current study was planned to investigate the relationship between nutritional status of CABG surgery patients based on BMI, biochemical analysis and diet history with wound healing and post-operative complications in adult patients.

Patients and Methods

The hospital-based prospective study was conducted at the Armed Forces Institute of Cardiology / National Institute of Heart Disease (AFIC / NIHD), Rawalpindi, Pakistan, from October 2017 to March 2018. Using homogenous purposive sampling,[12] sample size was calculated with the help of following formula:

P = prevalence of disease 30%
Z = Level of confidence 95%
d = error 5%

$$n = Z^2 P (1-P) / d^2$$
$$= (1.96)^2 \times (0.3) \times (1-0.3) / (0.05)^2$$
$$= 3.84 \times 0.3 \times 0.7 / 0.0025$$
$$= 0.8064 / 0.0025$$
$$= 322$$

Patients of either gender aged 30-70 years admitted in hospital for CABG surgery were included. Data of those who died during or after surgery were excluded. All patients were followed up from admission in hospital (pre-operative) to one week after discharge from hospital for sternal wound healing assessment. The study was approved by hospital Institutional Ethical Review board letter no. 26/7/ R & D 2017/29 and written informed consent was taken from all patients/family enrolled in the study.

Demographic and biochemical data was noted through detailed history-taking and from the hospital record during pre- and post-operative assessment for CABG surgery.

Pre-operative nutritional status of patients was assessed by anthropometric, biochemical, clinical and dietary (ABCD) method.[13] According to Asian BMI, the patients were divided into underweight (BMI<18.5), normal (BMI=18.5-22.9), overweight (BMI=23-24.9), moderate obesity (BMI=25-30) and severe obesity (BMI>35) groups[14]. Biochemical assessment comprised serum albumin (34-50g/L), random blood glucose (RBG) (≤200mg/dL), sodium (135-145mmol/L), potassium (3.2-5.2mmol/L), and haemoglobin (12-15g/dL). After clinical examination, dietary history was taken using the semi-quantitative food frequency questionnaire (FFQ).[15] The amount, frequency and type of the food consumed was recorded by using household utensils, like cup, glass, spoon, plate, as standard measures for portion size. Frequency of foods was also measured as daily and weekly. Patients were asked about any change in dietary pattern due to the existing diseased condition and were requested to report the information about dietary intake during the preceding 4 weeks according to routine dietary habits. Complete and accurately-filled FFQs were used to compose results by using a food database.[16,17]

All the patients who underwent CABG surgery were followed up for one week after discharge from hospital. The patients were asked to report to the cardiac surgeon after one week of discharge for sternal wound healing assessment. The scoring system used to assess the wound healing process was Additional treatment, Serous discharge, Erythema, Purulent exudate, Separation of deep tissues, Isolation of bacteria, and Stay as inpatient prolonged over 14 days (ASEPSIS).[18] Wound healing was categorised satisfactory healing, disturbance of healing, minor wound infection, moderate wound infection and severe wound infection. Post-operative parameters included stay in intensive care unit (ICU), length of stay in hospital, gastrointestinal (GI) infection (diarrhoea) and chest infection (cough and presence of sputum). Energy intake per kilogram of body weight of the subjects was compared with the recommendations of the American dietary guidelines matched for age, gender and physical activity level.[19]

Data was analysed using SPSS 21. Data was presented as frequencies and percentages or mean and standard deviation, as appropriate. Pearson's correlation was used to find out the association between independent and dependent categorical variables. One-way analysis of variance (ANOVA) was used to find out the effect of nutritional status on wound healing. Probability level of $p<0.05$ was considered statistically significant.

Results

Of the 330 patients, 16(4.8%) died within hospital. The final sample, as such, comprised 314(95.2%) patients; 273(86.9%) males and 42(13.1%) females, with an overall

Table-1: Pre-operative risk factors and biochemical association with wound healing.

Variable	Wound healing					P value
	Satisfactory healing N=252	Disturbance of healing N=23	Minor wound infection N=33	Moderate infection N=5	Sever wound infection N=1	
Diabetes	99(72.8%)	13(9.6%)	19(14.0%)	4(2.9%)	1(0.7%)	0.03*
Hypertension	150(78.5%)	13(6.8%)	22(11.5%)	5(2.6%)	1(0.5%)	0.32
Ex-smoker	52(74.3%)	8(11.4%)	10(14.3%)	-	-	0.24
Age	56.5±8.3	57.4±7.6	57.0±7.2	55.4±10.4	59.0±00	0.97
BMI kg/m^2	26.7±4.3	26.8±4.4	27.1±4.3	29.4±3.6	33.0±0	0.40
Haemoglobin	14.4±1.6	13.5±2.2	12.9±1.9	12.7±2.7	13.1±0	0.53
Blood glucose (R)	175.1±72.7	181.0±87.1	176.7±69.5	195.2±48.7	433.0±0	0.03*
Albumin	35.2±7.1	34.2±6.4	31.0±6.9	30.4±3.7	21.0±0	0.03*
Serum sodium	137.3±3.9	137.6±2.9	137.9±4.2	136.0±2	124.0±0	0.42
Serum Potassium	4.4±4.4	4.2±0.2	4.1±0.3	4.3±0.4	4.4±0	0.84

BMI: Body Mass Index.

Table-2: Comparison of daily macro and micronutrients of pre-operative CABG patients with US and AHA Dietary Guidelines.

Nutrients	Median	Range	US recommendations	AHA Guideline	P value
Energy (kcal/day)	1779	1006-3685	M (31-50 years) (2200-2400kcal/d) M (51+ years) (2000-2200 kcal/day) F (31-50 years) (1800 kcal/d) F (51+ years) (1600 kcal/d)	ND	0.679
CHO E%/day*	75	18-84	45-65 %‡	-	0.733
Protein E%/day	12	8-28	10-35%‡	15 %**	0.279
Fat E%/day	42	12-72	20-35%‡	≤ 15-30 %**	0.307
Saturated fat E%	-	-	NR	<10 %**	-
Trans-fat E%/day	1	0-38	NR	Limited amount**	0.047*
Carbohydrate g/day	197	54-411	M/F 130 g/d‡	-	0.709
Protein g/day	56	20-202	M (56 g/d) ‡ F (46 g/d) ‡	50-100 g/d**	0.674
Fat g/day	84	12-205	27 g‡	-	0.584
Saturated fat g/day	17	3-125	ND	-	0.701
Cholesterol mg/day	162	20-1010	300 mg/d‡	<200-300 mg/d**	0.538
Vegetables g/day	86	4-750	240 g/d ‡	-	0.400
Fruits g/day	43	0-450	160 g/d ‡	-	0.723
Dietary fibre g/day	15	3-41	M (30 g/d) ‡ F (21 g/d) ‡	≥25 g/d**	0.903
Sodium mg/day	1021	100-6320	M/F 1500 mg/d‡	<1800 mg/d**	0.216
Potassium mg/day	1525	448-4823	ND	2300-3900 mg/day**	0.374
Calcium mg/day	356	84-996	M/F 31-50 (1000 mg/d) † M/F 50+ (1200 mg/d) †	-	0.338
Magnesium mg/day	134	40-404	M/F (420 mg/d) †	-	0.386

CABG: coronary artery bypass graft, US: United States, AHA: American Heart Association.

* CHO E% (carbohydrate energy intake in %).

M = male, F = female, ND = not determined, NR = not recommended (indicates intake as low as possible while consuming a nutritionally adequate diet)

† From[15]

‡ From American dietary guidelines[18,32]

** From American heart association guideline[29]

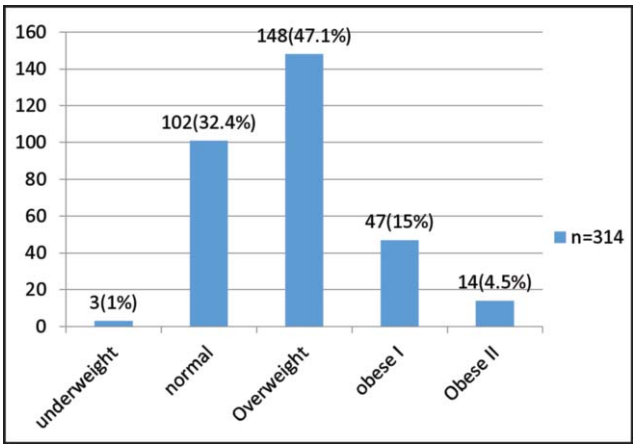

Figure: Distribution of body mass index in coronary artery bypass graft (CABG) surgery patients.

mean age of 56.6±8.3 years. The mean body mass index was 26.9±4.3kg/m^2 (Figure).

Mean serum albumin was 33.8±7.1 and 180(57.3%) subjects had low albumin levels <35 g/L pre-operatively. According to pre-operative analysis of risk factors, 197(62.7%) patients were in normoglycaemic state, 257(81.1%) were non-hypertensive, 70(22.3%) were current smokers and 244(77.7%) were non-smokers. The presence of DM and HTN was non-significant (p=0.06 and p=0.43, respectively)

BMI and sternal wound healing showed non-significant equation (p>0.05). Significant association was found between blood glucose and wound healing (p<0.05). Serum albumin showed significant association (p=0.03) with wound healing. No association was found of serum sodium, potassium and haemoglobin with wound healing (Table-1).

Overall, 133(42.1%) patients showed clinical signs and symptoms; 80(25.4%) with pale eyes, 25(7.9%) with leukonychia, 18(5.7%) with dry hair, and 10(3.1%) with dry skin.

All food groups and nutrients taken by the subjects showed non-significant relationship with wound healing (p>0.05) (Table-2).

Discussion

Malnutrition, according to the European Society of Clinical Nutrition and Metabolism (ESPEN), is under or over-nutrition that changes body composition and alters cell mass that leads to impaired physical and mental health and poor outcomes after diseased condition.[4] Gucu et al. concluded that malnutrition is associated with failure/delayed wound healing, change in inflammatory and immunity responses, life quality, hospital stay and morality.[20] The current study found that BMI was not associated with sternal wound infections. Satisfactory healing was observed more in overweight patients compared to normal-weight patients. Gillis and Carli suggested similar results.[21] A prospective study on CABG patients reported no risk of mortality and post-operative complications in overweight and obese populations.[22] Across-sectional study on 101 CABG surgery patients reported no association of obesity and post-operative complications.[23]

While obesity is a risk factor for post-operative complications, it remains a protective factor against post-surgical excessive bleeding in CABG surgery, as in obese patients, large abdominal pressure and mediastinal fat compress the bleeding site by increasing intra-thoracic pressure.[24] A study reported low risk of mortality after cardiac surgery in overweight people. While malnutrition (obesity) with diabetes is directly associated with sepsis, peri-operative myocardial infarction (MI) and increased hospital stay in cardiac surgery patients.[6] Similar results were reported by another study.[25] In the present study, diabetic patients showed satisfactory wound healing perhaps due to good diabetic control in pre-, peri- and post-operative phases. A study reported significant reduction in sternal wound infection with improved glycaemic control in the post-operative phase. In a study, 66% reduced risk of wound infection was reported by using intravenous (IV) insulin dosage to keep blood glucose <200mg/d.[26]

The present study revealed that albumin can be the indicator of pre-operative nutritional status and had significant association with poor wound healing. Patients with albumin <35mg/dl reported disturbance of wound healing in the present study in line with literature.[4] Hypo-albuminaemia was reported as an independent predictor of increased post-operative nosocomial infections, organ dysfunction and morbidity and mortality after cardiac surgery.[6] It is very clear that low body protein is related to anaemia, muscle weakness, poor wound healing, increased infection rate and impaired GI mobility.[27]

Generally, nutritional status is determined by various methods, including anthropometric measures, serum albumin, and total lymphocyte count (TLC). Different nutrition screening methods and tools based on subjective data analysis are used while other tools are based on clinical and biochemical data. It is important to use both subjective and objective data to assess the nutritional status to get more precise and accurate information.[28] Nutritional data showed statistically non-significant relationship, but there existed a clinical

significance of macro and micronutrients with sternal wound healing. Similar results have been reported in literature on this count.[28,29] It was stated that energy is essential for nitrogen synthesis, anabolism and wound healing. For collagen formation glucose is considered a major fuel compared to fat and protein.[29] On the basis of food group calculation, the current study population reported high intake of carbohydrate. A study concluded that in daily caloric intake, more calories come from cereal group followed by refined sugars.[29] It was reported that high-carbohydrate diet and insulin resistance (IR) contributes to the lipogenesis (metabolic formation of complex fats) and induce the synthesis of pro-inflammatory saturated fatty acids.[17] In the current study, the intake of saturated fatty acid and trans-fat was found to be very high. Trans-fats should be mentioned on food labels and provision of trans-fat-free products should reduce its intake to achieve the recommended level.[30] In the wound healing process, the role of fats is not very clear, but some studies reported anti-inflammatory effect of ω-3 fatty acids.[6]

In the present study, cholesterol intake was high in 57% participants. Some studies have reported the association between increased dietary cholesterol with increased CADs.[31] Vegetables and fruits provide several micronutrients. Like flavonoids, carotenoids, and vitamin C, that help in the immune functions and ultimately improve physiological functions, including wound healing.[32] It is an established fact that high intake of fruits and vegetables prevent CVDs and improve overall health. Very low intake of vegetables and fruits has been found to be harmful,[33] but the current study showed very low intake of fruits and vegetables. A meta-analysis reported that 3-5 servings of fruits and vegetables every day reduces the chances of chronic heart disease by 17%.[17] Another study supported the fact that antioxidant vitamins A, E and C show anti-inflammatory effects.[34]

Dietary fibre intake was reported low in the present study. Some studies have shown the association between high fibre intake and lower levels of low-density lipoprotein (LDL) and glucose, but fibre supplements are not associated with reduction in heart disease.[35] Some data suggest that high fibre diet have effect on high glycaemic load.[17]

It was very clear from the above discussion that pre-operative nutritional status plays an important role after CABG surgery.[5] Another study reported that nutrition correction might be effective in primary and secondary prevention, and goals should be set for healthy eating patterns that automatically support health.[17]

Conclusion

Low levels of albumin and poor blood glucose control before surgery was found to be associated with delayed wound healing. Nutritional intervention prior to CABG surgery may lead to reduced risk and complications during/after surgery. Obese patients who underwent CABG surgery had satisfactory wound healing. Obesity did not relate to poor wound healing, but appears to be a risk factor for post-operative wound healing. Besides, pre-operative hypo-albuminaemia was found to be a good indicator of poor nutritional status and had direct association with poor wound healing.

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