Multivariate Analysis of Factors Influencing Length of Hospital Stay after Coronary Artery Bypass Surgery in Tehran, Iran

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Abstract- Length of hospital stay (LOS) is a key indicator for hospital management. Reducing hospital stay is a priority for all health systems. We aimed to determine the length of hospital stay following Coronary Artery Bypass Surgery (CABG) based on its clinical and non-clinical factors. A cross-sectional study of 649 consecutive patients who underwent coronary artery bypass graft surgery was conducted in Imam Khomeini and Shariati university hospitals, Tehran, Iran. Data was analyzed by using non-parametric univariate tests and multiple linier regression models. Thirty seven independent variables including pre-operative, intra-operative and post-operative variables were analyzed. Finally, an appropriate model was constructed based on the associated factors. The results showed that 70.3% of the patients were male, and the mean age of the patients was 59.3 ± 10.4 years. The Mean (±SD) and median of the LOS were 11.7 ± 7.1 and 9 days, respectively. Of 37 investigated variables, 24 qualitative and quantitative variables were significantly associated with length of stay (p<0.05). Multiple linear regression analysis showed that independent variables including age, medical insurance type, body mass index, and prior myocardial infarction; admission day, admission season, Cross-clamp time, pump usage, admission type, the number of laboratory tests and the number of specialty consultation had more effect on the hospital stay. We concluded that some significant factors influencing hospital stay after CABG were predictable and modifiable by hospital managers and decision makers to manage hospital beds.

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Keywords: Coronary arteries bypass grafting; Length of stay; University hospital

Introduction

Coronary arteries bypass grafting (CABG) is one of the common and primary interventions for patients with coronary artery disease (1). This is the most frequent surgical procedures in many countries (2-3). Also, this procedure is increasing in Iran now (4). One of the Iranian reports of cardiothoracic surgery showed that 87.2% of the cardiac surgeries were isolated CABG (5). Today health systems attempt to reduce costs after major surgical procedures such as CABG surgery (6) because this procedure is account for more considerable costs in cardiovascular medicine than other interventions (7). Optimizing the hospital length of stay (LOS) is a promising alternative for costs management and efficient consumption of hospital recourses (8,9). It should be noted that both under-hospitalization and over-hospitalization have a negative impact on the resources and hospital process (10). In many countries, hospitals are focused on reducing the length of stay. In the United Kingdom, for example, the length of stay is a performance indicator for managers' payment. Therefore reducing hospital stay is a priority for health systems (11,12). Also, LOS is a key indicator of hospital resource consumption (13). LOS is an indicator used to assess the technical efficiency and bed management (14,15). A study showed that reducing one day of the hospital stay reduces the total cost of care by 3% (16). However, collecting comprehensive data on length of hospital stay is an important issue for managers and planners (17,18). Studies show that many factors impact on the LOS of patients undergoing CABG surgery.

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These factors include risk factors (including family history, Diabetes, hyperlipidemia, and hypertension) patient characteristics (sex. age, race, marital status, and patients' origin) and some clinical and non-clinical factors (6,19,20). Clarke classified these factors into two categories: supply factors (including Bed supply, hospital competition, Method of payment and Discharge policies) and demanded factors (including Socioeconomic status, disease severity, and Comorbidity) (12). We aimed to study the factors associated with hospital stay after Coronary Artery Bypass surgery.

Materials and Methods

Design and setting

This study was performed in Imam Khomeini and Shariati university hospitals affiliated with Tehran University of medical sciences (in Iran). These are two large hospitals with 970 and 570 beds. Imam Khomeini hospital has 18 cardio surgery beds, 8 cardio surgery intensive care units and 39 cardiology beds. Shariati hospital has 8 cardio surgery intensive care units, 7 post-intensive care units and 22 cardiology beds. These hospitals provide comprehensive services to all foreign patients and Iranian population.

Patients

We studied a total of 649 patients underwent isolated CABG surgery from among 970 patients admitted to the cardio surgery departments from Marches 2011 to July 2012. Inclusion criteria were: adults aged 18 years or more, elective or urgent admission (21) and patients with isolated CABG. We excluded the patients with emergency admission from this study because we wanted to investigate preoperational factors related to the length of stay. Therefore, admission type was divided into two categories (urgent and elective). Urgent admission was defined as surgeries performed within the first day of admission or the time of surgical consultation (22). Finally, 321 patients (33% of all patients) with emergency admission, mitral valve replacement (MVR) and aortic valve replacement (AVR) with or without CABG surgery and also patient's under18 years of age were excluded from the study. Patients with the uncompleted medical record were discarded from the Study.

Data collection and variables

We collected data for a one-year period. The data were obtained from the databases of cardio surgery wards, administrative data, and hospital medical records. In present study, independent variables were defined on the basis of credibility, objectivity, and prevalence. These variables were defined as follow:

-Demographic variables including age, sex (male or female), Place of residence (in Tehran or other countries), health insurance type (Iranian health insurance, social security medical insurance, rural health insurance and other), marital status (Single or married).

-Clinical history variables including admission type (urgent or elective), NYHA (I, II. III, IV, V), weight, height, rehospitalization, angina, chest pain, dyspnea (had and those who did not).

-Risk factors including (had and those who did not): smoking history, diabetes, body mass index (BMI), hyperlipidemia, hypertension, myocardial infarction (<3 months before operation), chronic obstructive pulmonary disease (COPD), cardiovascular disease, and cardiovascular attack (<2 week), the number of risk factors.

-Surgeon characteristics including sex, practicing year, degree (assistant professor, associated professor and professor)

-Postoperative and Preoperative variables including prescribed medications, the number of laboratory tests, the number of specialty consultations, the number of imaging services and radiography.

Intraoperative variables including operation during, the number of diseased vessels, cross clump time, perfusion time, Lima harvesting (good flow or acceptable), off or on-pump CABG.

Statistical analysis

The first, we reported a descriptive statistic of variables. Some variables, such as marital status, obstructive pulmonary disease (COPD), cardiovascular disease, surgeon sex and some of the preoperative and postoperative medications were removed from the variable list due to the little frequencies of their category. Then a statistical analysis was performed in six steps: (1) we used a Kolmogorov-Smirnov (KS) test to determine normality of dependent variable; (2) univariate analysis was performed by non-parametric tests (including Kruskal-Wallis, Mann-Whitney and spearman coefficient tests) to determine association of independent variables with LOS; (3) then significant variables were selected for the multiple linear regression analysis based on the significantly level ($p \leq 0.05$) (4) the missing values were controlled by pair-wise deletion method; and (5) backward regression method was used to identify independent factors that may be predictive of hospital length of stay. Variables with $P<0.10$ in the

backward regression analysis were entered into a multiple linear regression models (24). The potential effect of co-linearity was assessed by variance inflation factor (VIF<10) and condition number (CN<15) (25) (6). The linear regression model was built based on the relevant and significant variables.

Results

Table 1 describes the baseline characteristics of the study population.

Table 1. Clinical and non-clinical characteristics of patients (n=649)

Variables	N (%)	Variables	N (%)
Patients characteristics/Demographic data		**Cerebrovascular disease (CVD)**	0(0.0)
Age at surgery		**Malignancy**	0(0.0)
<50 years	122 (18.8)	**Immunosuppressive treatment**	0(0.0)
50—59 years	190 (29.3)	**Specifications of disease**	
60—69 years	210 (32.4)	**The number of diseased vessels**	
≥70 years	127 (19.6)	**One- diseased vessel**	58 (8.9)
Gender		**Two- diseased vessels**	142 (21.9)
Male	456 (70.3)	**Three or more diseased vessels**	449 (69.2)
Female	193 (29.7)	**Ejection fraction (EF)**	
Body mass index (BMI)		**Poor (<40 %)**	206 (34.6)
Underweight (<19)	23 (3.7)	**Moderate (41-49 %)**	121 (20.3)
Normal (20-24.5)	140 (22.2)	**Good (≥50 %)**	268 (45)
Overweight (25-29.9)	392 (62.2)	**Lima harvesting****	
Obesity (≥30)	75 (11.9)	**Good flow**	459 (80.5)
Marital status		**Acceptable**	11 (19.5)
Married	611 (96.5)	**Pump usage**	
Single	38 (3.5)	**On-pump**	550 (91.7)
Medical Insurance Types*		**Off-pump**	50 (8.3)
Social security insurance	255 (44)	**Admission status**	
Medical services insurance	226 (39)	**Elective**	587 (90.4)
Rural health insurance	68 (11.7)	**Urgent**	62 (9.6)
Others	30 (5.2)	**NYHA*****	
Uninsured	23 (3.8)	**Class 0- II**	440 (88.5)
Place of residence		**Class III – IV**	57 (11.5)
Tehran (capital)	268 (41.9)	**Surgeon characteristics**	
Others	371 (58.1)	**Gender of surgeon (male)**	649 (100)
Cardiac history		**Practicing years**	
Angina		**<10**	129 (22.9)
Yes	453 (69.8)	**11-20**	323 (57.3)
No	196 (30.2)	**>20**	112 (19.9)
Chest pain		**Surgeon degree**	
Yes	438 (67.5)	**Assistant professor**	267 (47.3)
No	211 (22.5)	**Associate professor**	244 (43.3)
Rehospitalisation		**Professor**	53 (9.4)
Yes	25 (3.9)	**Other factors**	
No	624 (96.1)	**Admission Day**	
Cardiac risk factors		**Saturday**	168 (25.9)
Diabetes	217 (33.4)	**Sunday**	125 (19.3)
Hypertension	303 (46.7)	**Monday**	111 (17.1)
Smoking history	196 (30.2)	**Tuesday**	88 (13.6)
Hyperlipidemia	178 (27.4)	**Wednesday**	56 (8.6)
Comorbidities		**Thursday**	72 (11.1)
Cerebral vascular accident (CVA)		**Friday**	29 (4.5)
No	641 (98.8)	**Season**	
>14 day	1 (0.2)	**Spring**	197 (30.4)
<14 day	7 (1.1)	**Summer**	182 (28)
Previous myocardial infarction (MI)	141 (21.7)	**Fall**	146 (22.5)
Chronic pulmonary disease (COPD)	0 (0.0)	**Winter**	124 (19.1)

* These insurance funds are the largest Iranian medical insurance shames (cover over 90 percent of Iranian population).
** Left internal mammary artery
***NYHA: New York Heart Association

A total of 649 patients underwent CABG, 70.3% were male. The mean age of the patients was 59.3±10.4 years, and 80.4 % of patients were under 70 years. The results of the study showed that 96.2% of patients were covered by one of the Iranian medical insurance schemes. 94.3% of patients didn't re-hospitalized previously. Most hospitalized patients had a chest pain and/or angina. Of all the 649 patients, 587 (90.4%) were admitted electively. The majority had an ejection fraction (EF) of more than 50%. In terms of admission days, slightly lesser than half were admitted during the Saturday and Sunday. Table 2 shows the descriptive of continuous variables and univariate factors associated with length of stay. The Mean (SD) and median of hospital length of stay were 117 ± 7.1 and 9 days, respectively. The Mean of ICU stay was 2.2 ± 1.5 days. Operation duration was 4.9 ± 0.8 hours. Based on the univariate analysis, we found that age at surgery (continuous), the number of risk factors, Cross-clamp time, the number of laboratory tests, the number of imaging services and the number of specialty consultation were significantly associated with length of hospital stay (P<0.05).

Table 2. Univariate analysis of continuous variables associated with LOS

Variables	Mean(±SD)	Median	*P.* value
Demographic variables			
Age at surgery (years)	59.6 (±10.4)	60	0.003
Wight (Kg)	71.6(±13.3)	70	0.81
Body Mass Index (BMI)	26.1(±4.9)	25.6	0.91
Number of risk factors	1.3(±1.04)	1	0.102
Operation data			
Cross-clamp time (min)	54.1 (±16.9)	50	0.039
Perfusion time (min)	92.9(±32)	89	0.352
Duration of surgery (hours)	4.9(±0.8)	5	0.13
Hospital services			
Number of laboratory test	12.2(±7.8)	11	<0.001
Number of imaging services	7.6(±2.2)	7	<0.001
Number of specialty	1.3(±1.2)	1	<0.001
Consultation Outcomes			
Preoperative say (days)	3.4(±3.9)	2	--
ICU length of stay (days)	2.2 (±1.5)	2	--
Postoperative stay (days)	8.3(± 5.4)	7	--
Total hospital stay (days)	11.7(± 1.6)	9	--

SD: standard deviation; ICU: intensive care unit; Risk factors including diabetes, Hypertension, hyperlipidemia, Smoking history

Also the results of Table 3 show that age, body mass index (BMI), marital status, medical insurance type, angina history, chest pain history, hypertension, smoking history, previous myocardial infarction, the number of diseased vessels, ejection fraction, pump usage, admission type, NYHA class, practicing years of surgeon, academic degree, admission day and season were significantly associated with length of stay (except sex, Place of residence, diabetes history, rehospitalization and lima harvesting). In terms of demographics, the length of stay hasn't significant deference between male and female. Married peoples stayed Around 2.5 days more than unmarried, and this was also found to be statistically significant (P<0.001). The older patients were hospitalized longer. The patients who were covered by medical services insurance plan were hospitalized longer. In terms of risk factors, those who had diabetes, hypertension and hyperlipidemia were hospitalized more than others. The mean LOS was significantly more in the moderate ejection fraction (41-49 %) than that of the other (P=0.034) (Table 3).

Of the 37 investigated variables, univariate analysis identified those 24 qualitative and quantitative variables were significantly associated with length of stay. Then by using a Multiple Linear Regression model these significant factors were assessed for their independent effect on the hospital stay. Qualitative variables verified as a dummy variables. The associated factors with LOS with a significant level less than 0.2 in the univariate analyzes were put in the multiple regression models.

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Table 3. Univariate analysis of categorical variables associated with LOS

Variables	Mean (SD)	Median	*P Value*	Variables	Mean (SD)	Median	*P Value*
Patients characteristics				**Hospital characteristics**			
Age <65 years	11.3 (±6.8)	9	0.009	**Number of diseased vessels**			
Age ≥65years	12.7 (±7.7)	11		**One- diseased vessel**	14(±8.2)	12	0.036
Male	11.6(± 6.7)	9	0.369	**Two- diseased vessels**	11.7(±6.7)	10	
Female	12.1(±7.8)	10		**Three or more diseased vessels**	11.4(±7.1)	9	
Body mass index				**Ejection fraction (EF)**			
Underweight (<19)	12(±4.1)	12	0.001	**Poor (<40 %)**	10.8(±6.5)	9	0.034
Normal (20-24.5)	13.6(±8)	12		**Moderate (41-49 %)**	12.7(±7.6)	11	
Overweight (25-29.9)	10.6(±6.2)	9		**Good (≥50 %)**	11.08(±6.1)	9	
Obesity (≥30)	13.6(±9.6)	11		**Lima harvesting**			0.155
Marital status				**Good flow**	12(±7.2)	10	
Married	11.9(±7.2)	10	0.036	**Acceptable**	12.8(±7.6)	11	
Unmarried	9.4(±6.2)	7		**On- Pump CABG**	11.11(±6.7)	9	0.001
Medical Insurance Types				**Off –Pump CABG**	17.2(±9.1)	15	
Social security insurance	11.5(±7.3)	9	0.007	**Elective**	12.1(±7.3)	10	0.001
Medical services insurance	12.5(±7.3)	10.5		**Urgent**	8.5(±3.9)	7	
Rural health insurance	9.5(±4.8)	8		**NYHA Class 0- II**	11.6(±7.1)	9	0.021
Others	10(±6.4)	7.5		**NYHA Class III – IV**	14.4(±8.8)	12	
Uninsured	11.7(±8.2)	9		**Practicing years (surgeon)**			0.001
Living area				**<10**	17.1(7±9)	15	
Tehran	11.8(± 6.7)	10	0.613	**11-20**	10.2(±5.3)	8	
Other cities	11.7(±7.4)	10		**>20**	12.8(±8.7)	11	
Cardiac history				**Academic degree (surgeon)**			
Angina	11(± 6.7)	9	0.001	**Assistant professor**	13.3(±7.6)	12	0.001
No Angina	13.5(±7.7)	12		**Associate professor**	10.2(±5.3)	8	
Chest pain	11(±6.6)	9	0.001	**Professor**	16.6(±10.2)	14	
No Chest pain	13.2(±7.9)	11		**Admission Day**			
Rehospitalisation	11.2(±4.7)	10	0.588	**Saturday**	11.2(±7.2)	9	
No Rehospitalisation	11.7(±7.1)	9		**Sunday**	12.7(±8.4)	10	
Diabetes	12.2(±7.1)	10	0.101	**Monday**	11.3(±6.8)	9	0.048
No Diabetes	11.5(±7.1)	9		**Tuesday**	11.2(±7.1)	9	
Hypertension	12.4(±7.6)	10	0.018	**Wednesday**	10.9(±4.8)	10	
No hypertension	11.1(±6.5)	9		**Thursday**	12.3(±6.5)	11	
Smoker	10.9(±7.1)	8	0.004	**Friday**	13.9(±5.9)	12	
No Smoker	12.1(±7)	10		**Admission Season**			
Hyperlipidemia	12.9(±7.9)	11	0.014	**Spring**	9.3(±4.8)	8	
No hyperlipidemia	11.3(±6.7)	9		**Summer**	10.8(±5.7)	9	0.001
Prior MI	14(±8.1)	12	0.001	**Fall**	12.5(±6.1)	12	
No Previous MI	11.1(±6.7)	9		**Winter**	16(±10.3)	12.5	

*Mean and Median length of stay; MI: myocardial infarction

Based on the backward method, the associated factors with LOS were determined as following: age at surgery, medical insurance type, BMI, prior myocardial infarction, admission day, season, Cross-clamp time, pump usage, admission type, the number of laboratory tests and the number of specialty consultation (P<0.05) (Table 4).

Table 4. Multiple linear regressions analysis of factors associated with length of hospitalization

Factors	Unstandardized Coefficients	Std.Error	Standardized Coefficient	*P* Value
(Constant)	-9.241	3.264	--	0.005
Patients characteristics				
Age (continues)	0.065	0.029	0.096	0.025
Medical insurance Status				
Social security insurance	1.536	0.651	0.105	0.019
Rural health insurance	2.036	1.037	0.088	0.05
Risk factors & cardiac history				
BMI 25-29.9 (Overweight)	2.419	0.629	0.166	<0.001
Prior myocardial infarction (MI)	2.192	0.748	0.127	0.004
Admission status				
Admission type (elective)	3.184	1.024	0.131	0.002
Admission day (on Thursday)	2.478	1.090	0.098	0.024
Admission season				
Spring	5.787	0.892	0.374	<0.001
Summer	4.380	0.912	0.276	<0.001
Fall	3.662	0.946	0.215	<0.001
Intra-operative factors				
Cross-clamp time (min)	0.041	0.018	0.098	0.024
On-Pump CABG	-5.499	1.115	-0.213	<0.001
Consultation and laboratory services				
The number of laboratory tests	0.127	0.046	0.141	0.006
The number of specialty consultation	1.431	0.291	0.248	<0.001

Discussion

In the recent years, the health systems have focused on the hospital length of stay indicator as an important contributor to medical costs and economic indicator (26). LOS is a commonly used indicator of hospital management (27). Determination of LOS can effectively help to manage hospital resources and improve efficiency (28). In the current study, we investigated the hospital length of stay for patients underwent CABG and its related factors in two university and referral hospitals. The results of the study showed that the LOS of patients was 11.7 ± 1.7 days. It is noted that isn't yet a standard LOS of patients. For example, Weintraub et al. and Khairudin defined more than 10 and 14 days as prolonged LOS in CABG patients respectively (13, 29). However, Raw LOS is a source of bias in comparing the performance of hospitals (30). Therefore, the methods must be used to identify clinical and demographic subgroups of patients associated with the length of stay (31). The risk-adjusted length of stay is a common and applied the method for calculating optimal LOS based on the demographic and clinical risk factors (30-32). Risk-adjusted LOS will be able to improve efficiency by identifying specific subgroups of patients based on the various factors (33). The results of the Multiple Linear Regression showed that age, social security insurance, body mass index 25-29.9 (overweight patients), prior myocardial infarction (MI), admission on Thursday, Admission on spring, summer and fall, cross-clamp time, on-pump CABG, elective admission, the number of laboratory tests and the number of specialty consultations were significant associated factors with LOS. This study showed that increasing patients age lead to increase the hospital stay. As, for every unit increase in age, a 0.096 unit increase in LOS is predicted. Similar findings were noted by Weintraub *et al.,* Khairudin and Cocker (13,29,34). It can be said that CABG surgery in the elderly patient has certain risks. Thus, they require longer incubation, longer ICU stay,

and longer hospital stay (35). The proportion of elderly is projected to double in Iran (36). Therefore, it is important to address the medical needs of elderly peoples. The results of the study showed that risk factors including diabetes, hypertension and hyperlipidemia increased the hospital stay. Several studies confirm our findings too (19,29,37). A study showed that diabetes team intervention can reduce the hospital length of stay to 2 days (38). In our study, patients with BMI<25 (underweight and normal BMI) were hospitalized longer. Perrotta *et al*., concluded that patients with moderately increased BMI were hospitalized more than other (39). A study indicated that hospital stay after surgery was the longest for patients with an underweight BMI (40). In the current study, a hospital stay of patients with prior MI was 1.2 more than other. In some studies, obtained the similar results (3,4,6,13). A hospital stay of the patients admitted on Thursdays were longer (Standardized Coefficients Beta=0.098). Probably because in the weekend less diagnostic and clinical procedures have been taken, and they usually are postponed until the next week (10). Therefore, planning admission process and bed management (for elective patients) should be implemented to manage hospital resources. Thompson *et al*., and Horwich *et al*., obtained similar results. They concluded that patients admitted on a weekend have longer LOS (41,42). This study showed that the patients who were admitted in spring, summer and fall were hospitalized longer, respectively. According to Konuralp *et al*., there wasn't a significant difference in outcome between patient who had undergone bypass grafting surgery in the winter or summer (43). Nemati conducted a study in private hospitals among patient who had undergone CABG in Shiraz, Iran. He concluded that there were no such significant differences in the LOS between the four seasons. However, there aren't many data on the association between seasonal variety and hospital outcomes (44). Cross-clamp time was one of the significant predictors of LOS (mean 54.1 ± 16.9 min, *P*=0.024). LOS of the patients with higher cross-clamp time was longer that is; for every unit increase in cross-clamp time (minute), a 0.098 day increase in LOS is predicted. Different studies show the contradictory results. Schwartz *et al*., concluded that clamp time does not extend the ICU or hospital length of stay (45). A study showed that morbidity (including the length of stay and postoperative heart function) decreased concurrently with the decreases in cross-clamp times (46). Increased cross-clamp time significantly associates with post-operative morbidity and mortality (47,48). However, with a decrease in cross-clamp time can decrease the length of stay and other post-operative morbidities. On-pump usage was an important factor for the decrease in LOS (Beta= -0.213). According to Sisillo *et al.,* and Sellke *et al*., there wasn't significant difference between on-pump and off-pump coronary surgery (49,50). Hernandez *et al*., concluded that patients with off-pump surgery were hospitalized shorter (51). Also, another study showed that hospital stay duration was longer for on-pump CABG (52). Therefore to answer the questions of whether either surgery method and in which patients is suitable, a comprehensive and large-scale study is required. In the present study, mean of the hospital stay was 12.1 and 8.5 days for elective and urgent patients respectively (*P*=0.002, Beta=3.184). Ravangard *et al*., reported that LOS of the elective patients was longer. The result of this study is consistent with our results. By reducing the pre-operation hospital stay can reduce total LOS. For this purpose fast-tracking strategy, discharge planning and other effective interventions can be used. Also, same-day patient's admission can reduce hospital stay and hospital costs (19).

According to standardized coefficients, the number of laboratory tests and clinical consultation had a significant effect on the length of stay. A large number of pre-operative routine tests and delay in results lead to increase the pre-operation length of stay (10). Also, inefficient laboratory performance leads to delays in diagnosis and treatment and finally inappropriate care (53). Therefore, rapid diagnosis is a requirement for good patient outcomes (54). Specialty consultation was significantly associated with a hospital stay. LOS of the Patients with a large number of Specialty consultations was longer. Yoon *et al*., reported that specialty consultation was associated with prolonged stay duration, and there was a significant difference between services consulted (55). However, reducing inappropriate specialty consultation and managing consultation teams decrease the LOS of the patient's undergone CABG surgery. It is noted that reducing the length of stay can lead to increase the hospital costs. Therefore, managing hospital length of stay and its associated factors means managing hospital costs and resources. Major limitations of this study were: the first, the study has been conducted only, in general, university hospitals and the results probably cannot be generalized to other hospitals. The second, some of the data were gathered manually from patient charts and hospital documents that some of them were incomplete.

The results revealed that many factors including

preoperative, intra-operative and postoperative variables were associated with length of stay of patients underwent CABG. Some of the factors (including admission day, cross-clamp time, pump usage, admission type, the number of laboratory tests and the number of specialty consultation) are controlled by managerial teams and some of the factors (including age, medical insurance type, BMI, prior MI, and season) aren't controlled. Therefore, clinicians, hospital planner and policy makers can adjust the hospital stay by using timely and appropriate interventions. For future research, we suggest a stochastic simulated study to investigate more phenomena involving the length of stay in CABG patients.

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