Influence of Cardiac Risk Factors and Medication on Length of Hospitalization in Patients Undergoing Major Vascular Surgery

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Major vascular surgery is associated with a long in-hospital length of stay (LOS). Cardiac risk factors identify patients with an increased risk. Recent studies have associated statin, aspirin, and β-blocker therapies with improved postoperative outcome. However, the effect of all these factors on LOS has not been defined. Our aims were to determine the effect of cardiac risk factors and (preventive) statin, aspirin, and β-blocker therapy on LOS and to deduce from these factors a model that predicts LOS. In total, 2,374 patients from 1990 to 2004 were enrolled. Mean LOS was 18 ± 9 days. Cardiac risk factors that were significantly associated with LOS in the multivariable analysis were age, previous heart failure, hypertension, diabetes mellitus, renal failure, and chronic obstructive pulmonary disease. Statin and aspirin use was associated with a shorter LOS. Beta blockers shortened LOS only in patients with underlying coronary artery disease. Together, these factors explained 14.1% of the variance in LOS. In conclusion, in-hospital LOS in patients who undergo major vascular surgery can be predicted more accurately by clinical cardiac risk factors. A significant decrease in in-hospital LOS was achieved with statin, aspirin, and β-blocker therapies. **(Am J Cardiol 2006; 97:1423–1426)**

Because health care costs are increasing, hospitals have been forced to use their scarce resources as efficiently as possible. A shorter in-hospital length of stay (LOS) increases the average income for each bed per day, because LOS accounts for 31% of hospital costs in surgical inpatients.[1] Major vascular surgery is commonly performed and associated with a long and variable LOS due to postoperative events, such as heart failure, myocardial infarction, and stroke. Research has focused primarily on the identification of risk factors that are associated with an increased perioperative cardiac event rate to improve postoperative outcome by treatment of underlying risk factors. Recently, several patient characteristics have been associated with an increased risk of prolonged LOS due to perioperative events.[2–7] Because recent studies have suggested an association between cardioprotective medical therapy (i.e., statin, aspirin, and β blockers) and a decreased risk of postoperative complications,[8–16] we hypothesized that a model that was based on cardiac risk factors and cardiopreventive medical therapy would predict LOS more accurately and, hence, more efficient hospital planning could be performed.

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The Erasmus Medical Medical Center (Rotterdam, The Netherlands) is a metropolitan university hospital that acts as a tertiary referral center for ~30 affiliated hospitals. Between 1990 and 2004, 2,374 noncardiac vascular surgical procedures, including aortic aneurysm repair, carotid enterectomy, and peripheral vascular surgery, were performed in patients who were >15 years of age in our center. We excluded 484 procedures (20.4%) that resulted in a LOS >90 days. LOS was defined as the number of days from the date of hospital admission to the date of hospital discharge. Patients were included many times because they were admitted for vascular surgery on the understanding that these procedures were >30 days apart. Thus, the operation (not the patient) was the unit of analysis, which is consistent with clinical practice.

Based on hospital records and personal interviews at the time of surgery, a medical history was recorded. Each patient's medical history was classified according to the *International Classification of Diseases, Ninth Revision* (ICD-9). For this study, we used medical conditions that have been associated with an increased risk of perioperative cardiovascular complications, including diabetes mellitus (ICD-9 code 250), myocardial infarction (ICD-9 codes 410, 411, and 412), angina pectoris (ICD-9 codes 413 and 414), previous heart failure (ICD-9 code 428), cerebrovascular accident (ICD-9 code 430), renal disease (ICD-9 code 580),

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Table 1
Patient characteristics

Factor	No. of Patients	Median In-Hospital LOS (quartile)	p Value
Men	1,665 (88%)	13 (7.25–22)	0.183
Age ≥70 yrs	928 (49%)	15 (8–23)	<0.001
Previous myocardial infarction	612 (32%)	13 (7–21)	<0.001
Angina pectoris	370 (20%)	14 (8–21)	0.156
Previous heart failure	119 (6%)	17 (10–29)	<0.001
Previous stroke	350 (19%)	9 (6–18)	<0.001
COPD	326 (17%)	17 (12–26.25)	<0.001
Renal failure	125 (7%)	16 (11–27.5)	<0.001
Diabetes mellitus	205 (11%)	14 (7.5–24)	0.321
Hypertension	908 (48%)	14 (8–21)	0.037
Hypercholesterolemia*	262 (14%)	12.5 (8–17)	0.129
Previous coronary artery bypass graft	257 (14%)	15 (8–22)	0.070
Percutaneous coronary intervention	66 (3%)	12 (6–21.25)	0.544
Statins	473 (25%)	12 (7–17)	<0.001
Diuretics	300 (16%)	15 (9–24)	<0.001
Angiotensin-converting enzyme inhibitor	547 (29%)	14 (8–22)	0.053
Calcium antagonists	636 (34%)	14 (9–21)	<0.001
Nitrates	321 (17%)	15 (9–24.5)	<0.001
β Blockers	618 (33%)	14 (8–20)	0.219
Digoxin	44 (2%)	13.5 (7.25–22.75)	0.775
Aspirin	789 (42%)	8 (6–16)	<0.001
Warfarin derivatives	292 (15%)	15 (9–25)	<0.001
Urgent surgery	169 (9%)	14 (9–22)	0.527
Aortic surgery	1,021 (54%)	16 (12–23)	<0.001
Carotid surgery	534 (28%)	7 (5–8)	<0.001
Peripheral surgery	1,057 (56%)	14 (9–23)	<0.001

* Removed from analysis due to a high correlation with statins.

hypertension (ICD-9 code 401), and chronic obstructive pulmonary disease (COPD; ICD-9 codes 490 to 496). Medical therapies (i.e., statins, β blockers, and aspirin) were noted in all patients.

Data analysis was performed with SPSS 11.5 (SPSS, Inc., Chicago, Illinois). Continuous data are presented as median values and corresponding 25th and 75th percentiles, and dichotomous data as numbers and percentages. Patient characteristics are listed in Table 1. Hospital LOS was not normally distributed. Therefore, the relation across clinical characteristics, cardiovascular medication, and LOS was first evaluated with Mann-Whitney univariate tests. For these tests, a p value <0.05 was considered statistically significant.

All variables were entered into the multivariate model, irrespective of results of univariate analysis. We used backward linear regression to construct a multivariate model that predicted LOS. All variables were entered into the equation and subsequently removed until all remaining variables had a p value <0.10.

In total, 2,374 patients, excluding 484 patients whose LOS was gt;90 days, mostly because they were on a waiting list for a nursing home facility or rehabilitation center, were enrolled in the study. Among these patients, 1,021 underwent aortic surgery, 1,057 underwent peripheral vascular surgery, and 534 underwent carotid endarterectomy. In-hospital mortality was 7.2% (137 of 1,890 patients).

Table 2
Results of multivariate analysis

Factor	Effect on LOS (days)	Significance	95% CI
Constant	9.756	<0.001	5.678 to 13.833
Male gender	−2.282	<0.001	−3.582 to −0.982
Previous heart failure	2.877	0.031	0.263 to 5.490
COPD	1.871	0.026	0.222 to 3.519
Hypertension	−1.212	0.041	−2.376 to −0.047
Diabetes mellitus	2.341	0.021	2.313 to 0.021
Renal failure	2.349	0.069	−0.181 to 4.879
Age (yrs)	0.141	<0.001	0.088 to 0.194
Statins	−3.153	<0.001	−4.581 to −1.725
Aspirin	−1.171	0.085	−2.501 to 0.160
Aortic surgery	2.823	<0.001	1.254 to 4.392
Carotid surgery	−7.078	<0.001	−9.108 to −5.047
Peripheral surgery	2.273	0.004	0.736 to 3.810

CI = confidence interval.

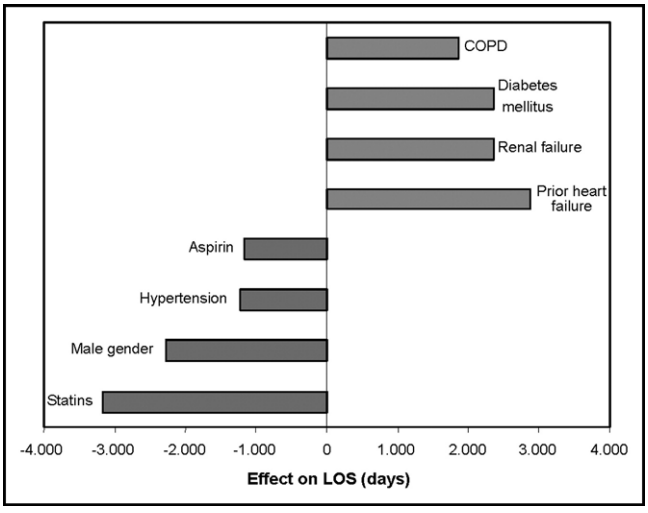

Figure 1. Factors that influence LOS.

Univariate analysis showed that advanced age, previous myocardial infarction, congestive heart failure, previous cerebrovascular accident, hypertension, renal dysfunction, and COPD were associated with a prolonged LOS. Importantly, statin and aspirin use was associated with a shorter LOS. All variables were then entered into multivariable analysis. The model that was developed from these factors explained 14.1% of variance in LOS. Outcomes of multivariate analysis are presented in Table 2 and represented in Figure 1.

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The main finding of this study was an association between LOS and clinical risk factors, such as age, heart failure, and COPD in patients who underwent major vascular surgery.

Importantly, medical therapy, such as aspirin and statin use, which is commonly associated with a decreased postoperative morbidity, was also associated with a shorter LOS. An effect of β blockers on LOS could be observed only in high-risk patients with proved coronary artery disease. This finding is in line with the cardioprotective effect of β blockers on postoperative cardiac events, which also demonstrated a beneficial effect only for those patients with multiple cardiac risk factors or a positive dobutamine stress echocardiographic result as a marker of significant coronary artery disease.[12] The combined information of risk factors and medical therapy enables the treating physician to plan LOS more efficiently for patients who undergo vascular surgery. Patients who were $\geq$70 years of age and had a previous myocardial infarction and angina pectoris had an extended LOS compared with those without these risk factors. However, LOS might have been shorter if aspirin, statins, and β blockers had been prescribed.

The relation between these risk factors and LOS is complex. Advanced age is a well-known risk factor that is associated with a longer LOS because co-morbid conditions are more prevalent in the elderly, and, importantly, early discharge depends on not only adequate support systems at home but also the availability of skilled nursing facilities. These results have been confirmed in a Veteran Affair study that evaluated >8,000 patients who were $\geq$80 years of age and had a prolonged LOS after major vascular surgery.[4] Another important risk factor is COPD. Patients with COPD, based on a preoperative pulmonary function test (forced expiratory volume in 1 second <70%), had a prolonged LOS. Such pulmonary complications may result in prolonged mechanical ventilation and LOS in the intensive care unit. Whether preoperative evaluation and perioperative medical therapy such as steroids can shorten LOS has yet to be determined, although the recent introduction of less invasive endovascular procedures may have a beneficial effect on pulmonary function in those patients with COPD. Cardiac risk factors such as heart failure are a well known for postoperative morbidity and prolonged LOS.[4,5,7] Importantly, cardiovascular medical therapies, such as statins, aspirin, and β blockers in high-risk patients, were associated with a shorter LOS. The effect of β blockers on perioperative morbidity in high-risk patients is well known. As shown by the study of Poldermans et al,[13] β blockers were associated with an improved postoperative outcome in high-risk patients, i.e., those with $\geq$2 risk factors and especially those with proved coronary artery disease. Further, a recent study by the Perioperatible Beta-Blockade (POBBLE) Investigators[16] showed that β blockers decreased the time from surgery to discharge (LOS) in patients who underwent infrarenal vascular surgery. The potential effects of statins and aspirin need to be confirmed in large prospective studies that evaluate potential side effects, such as an increased bleeding tendency or myopathy in relation to a shorter LOS.

A limitation of the study is that diabetes mellitus was noted as a dichotomous variable, although studies of patients who undergo cardiac surgery have associated regulation of diabetes mellitus with postoperative outcome.[17] Therefore, we were unable to assess the influence of diabetes regulation (tight vs loose) on LOS.[17,18]

In conclusion, the model we developed explains 14.1% of variance in LOS and enables the treating physician to plan surgical procedures more efficiently. Other factors that might explain variance in LOS are intraoperative factors (i.e., blood loss and surgical complications) and postoperative care (i.e., availability of a nursing home). The effect of these intra- and postoperative factors is very high, which explains the relatively low explained variance. However, all variables included in the multivariate stage were found to have a significant influence on LOS. Therefore, this information should be used in the preoperative planning stage. To improve planning for patients who undergo major vascular surgery, all risk factors (pre-, intra-, and postoperative) have to be included in a prognostic model that will be further refined in relation to patients during hospital LOS.

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