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HOSPITAL MORBIDITY AND PROLONGED ICU STAY AFTER CORONARY ARTERY SURGERY IN NORK MARASH MEDICAL CENTER, YEREVAN, ARMENIA

Lusine Abrahamyan, MD, MPH
Anahit Demirchyan, MD, MPH
Michael E. Thompson, MS, DrPH

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Abstract

Background. Hospital mortality and morbidity are one of the main outcome measures of coronary artery bypass grafting surgery (CABG). The objective of the study was to evaluate isolated CABG associated rates of hospital morbidity, severe morbid event and prolonged ICU length of stay and assess the determinants of the latter two quality indicators in Yerevan Nork Marash Medical Center (NMMC).

Methods. The study utilized a retrospective medical record review design in a unique cardio surgical center of Armenia: NMMC. All patients undergoing isolated CABG surgery at NMMC in 2003 were enrolled in the study. For all patients (n=391), data on preoperative characteristics, hospital mortality, morbidity, and ICU length of stay were retrieved.

Results. The observed crude in-hospital mortality was 2.05% (8 cases), which was lower as compared with the predicted mortality rate calculated by EuroSCORE (2.34%). Overall, 29.2% of the study population experienced a morbid event. Postoperative arrhythmia had the highest frequency among all postoperative complications (17.6%). Serious hospital morbidity rate (hospital death, wound infection, mediastinitis, cerebrovascular event [TIA/stroke], renal failure/dialysis, respiratory failure leading to tracheostomy, pneumonia, ARDS, and cardiac re-operation) was 5.9% (n=23). The final logistic regression model of serious morbid events identified the following predictors: previous cardiac surgery, drug allergy, poor EF, diabetes, and left main stem disease. Of all patients, 72.7 % (n=275) had ICU length of stay less than or equal to 48 hours and 9.5 % (n=37) had prolonged ICU stay (3 days and more). The mean EuroSCORE was significantly different between the groups of patients with ICU stay >= 3 days versus those with a stay of <3 days (p=0.002). Multivariable logistic regression analyses revealed 4 independent predictors of prolonged ICU stay at NMMC: age, no sinus rhythm, previous cardiac operation, and hypertension.

Conclusions. In 2003, the rates of hospital mortality, morbidity, and prolonged ICU stay in isolated CABG patients at NMMC were comparable to other major international cardio surgical centers. The results of the study indicated the groups of patients with previous cardiac surgery, drug allergy, poor EF, diabetes and left main stem disease have an increased risk to develop serious hospital morbid events. Older patients and patients with no sinus rhythm, previous cardiac operation and hypertension are in risk to have prolonged ICU stay. Further research with larger sample size is recommended for more accurate assessment of the predictors of these outcomes.

1. INTRODUCTION/BACKGROUND INFORMATION

Coronary artery bypass grafting is considered as the most accepted method for myocardial revascularisation in multivessel coronary artery disease (1). There is an increasing attention paid to the outcomes after CABG: operative mortality, morbidity, patients' length of postoperative stay, ICU length of stay, quality of life, etc (2, 3). These results could be compared between health care institutions/ providers and could widely differ across the countries depending on the patient population and the quality of provided care.

Outcomes after CABG, both mortality and morbidity, are determined by the preoperative status of the patient. Some of the patient characteristics defined as core variables play important role in these outcomes: patient age, gender, left ventricular ejection fraction, diabetes, small body size, different commorbidies (diabetes, renal failure), etc (3, 4). Besides preoperative factors, CABG outcomes are influenced by surgical and anesthetic techniques, cardiopulmonary bypass if applied, and efficacy of myocardial protection, patient homodynamic management, and patients' care at the Intensive Care Unit (ICU) (5).

CABG associated morbidity and its predictors

Although complications of cardiac surgery may not be fatal, they can significantly impact a patient's functional status, quality of life, and may often pose serious threats to a patient's long-term survival and functional capabilities after CABG (6). In surgeon's daily decision-making process, the probability for the occurrence of a major morbid event needs to be an important concern (6). *Neurological events* are among the most frequently occurring CABG operative complications. Reported rates of stroke range from 0.4% to 13.8% (1). Some possible predictors of this complication include prior stroke, hypertension, increased age, diabetes mellitus, and athersoclerosis of aorta and carotid artery (1, 7). *Deep sternal site infection* is associated with substantial morbidity and mortality (prevalence varies between 0.7% and 3.9%) (1). Predictors include obesity, re-operation, use of internal mammary arteries, diabetes, etc (1,6,7). The predictors of *postoperative renal dysfunction,* which can occur in 3.5% of cases, include advanced age, a history of congestive heart failure, prior renal disease, and previous bypass operation (1,6,7). Postoperative angina, myocardial infarction, arrhythmia, bleeding, and re-operation are among the other CABG surgery associated complications (6, 7).

Post CABG ICU length of stay

As already emphasized, a patient prognosis at arrival to the ICU could be different from the preoperative prognosis (5). ICU length of stay and risk-adjusted ICU mortality can be used to assess the quality of care in this department. ICU length of stay can be reported both as continuous data and dichotomous data. In the case of latter, a variable of prolonged ICU length of stay is defined as intensive care treatment for three postoperative days or longer. Prolonged ICU stay could be experienced by 37.1% of patients undergoing CABG procedure (8). Among the identified predictors of prolonged ICU stay are lung disease, no-sinus rhythm (atrial or ventricular fibrillation, AV block, etc), serious valve pathology, re-operation, no-elective (urgent or emergent) operation, and cardiopulmonary bypass (CPB) procedure (9).

Since March 2001, with the collaboration of American University of Armenia (AUA) Center for Health Services Research and Development (CHSR), there is an ongoing Quality Assurance Project in the Nork Marash Medical Center (NMMC). NMMC provides a wide range of cardiological and cardio surgical services to adult and pediatric populations of Armenia. More than 700 various cardio surgical operations were performed at NMMC in

2003, out of which more than half accounted for isolated CABG procedure. No previous study evaluated the quality of CABG procedure in terms of its outcomes. Considering the efforts for continuous quality improvement, it was imperative to evaluate the outcomes of CABG procedure at the center in terms of hospital mortality, morbidity and ICU length of stay of the patients. The data will enhance the self-assessment and peer assessment activities at the center and contribute to the improvement of quality of care. The study evaluated isolated CABG procedure associated hospital morbidities, severe morbid events, prolonged ICU stay, and assessed the determinants of the last two measurements.

The research questions of the study were:

- What was the rate of isolated CABG associated hospital morbidity? What was the rate of serious hospital morbid events of this procedure at NMMC in 2003? What were the predictors of serious postoperative morbidity?
- What were the predictors of prolonged ICU stay after isolated CABG procedure at NMMC?

The objectives of the study were:

- Describe the profile of patients who passed isolated CABG at NMMC in 2003
- Measure the rate of all CABG associated operative complications
- Assess the risk factors of serious hospital morbid events after isolated CABG surgery at NMMC
- Assess the risk factors of prolonged ICU stay after isolated CABG procedure at NMMC
- Define the areas where hospital performance needs to be concentrated and resources allocated (particular patient groups for specific outcomes) for continuous quality improvement.

2. METHODS

2.1. Study design

The study utilized a design of retrospective review of surgical medical records, surgical database, and Structured Encounter Forms (SEF) including all isolated CABG surgeries from January 1, 2003 through December 31, 2003.

The term CABG in this study refers to ***isolated CABG*** and does not include myocardial revascularization performed in association with other procedures, such as cardiac valve replacement or repair, resection of left ventricular aneurysm or other cardiac operations.

The AUA/NMMC collaborative project (ANP) team and surgical team of NMMC discussed together the definitions of both dependent and independent variables included in the study (Appendix 1).

2.2. Study protocol

All patients were examined by the cardiologists of Adult Cardiology Clinic (ACC) prior their admission to the Inpatient Clinic independent from the type of visit (elective or urgent). After this encounter, a SEF was completed for the patient. These SEFs, surgical medical records, and surgical database were reviewed for all selected patients. For many variables, this

allowed to double check the information and handle the missing data. Study instrument is presented in Appendix 2.

2.3. Study population

The study population consisted of all patients undergoing isolated CABG procedure at NMMC from January 1, 2003 through December 31, 2001. Overall, information on 394 patients was collected and entered in a computerized database.

3. ETHICAL CONSIDERATIONS

The study involved secondary data analysis and possessed no risk for patients. Furthermore, the study was considered as a part of an internal evaluation process in the scope of Quality Assurance Project at NMMC. However, approval to access medical records, surgical database and SEFs was obtained from Medical Board of NMMC prior to initiating the study. All records were reviewed in the hospital to ensure patient confidentiality.

4. STUDY LIMITATIONS

Although the definitions of variables were discussed with the medical staff, it could be possible that they varied across the residents and surgeons, especially considering the retrospective design of the study.

Six variables (smoking history, other than drug allergy, family history of hypertension, ischaemic hearth disease or sudden cardiac death, physical activity, hypercholesterolemia) were excluded from the analysis because of a high proportion of missing information (more than 10% of cases) in the SEFs. On the other hand, however, these missing variables could potentially have a major importance in studying the outcomes of CABG surgeries.

Two final logistic regression models for serious hospital morbidity and prolonged ICU stay were developed in this study. A logistic regression model cannot include every risk factor, especially factors with low incidence. There were too few cases to develop reliable univariate risk estimates for several predictive factors, such as COPD, prior cerebrovascular accidents, poor ejection fraction, etc. A larger sample size is needed for more accurate conclusions.

5. DATA ANALYSES

SPSS 11.0 statistical software was used for single data entry. Data analyses were performed using SPSS 11.0 and STATA 7.0 statistical software. For the outcomes of serious morbid event and prolonged ICU stay, univariable logistic regression analyses were performed to find significantly associated variables. Continuous variables were plotted using a locally weighted smoothing scatter plot technique to assess linearity on the logistic scale. In the next step, multivariable logistic regression analyses were performed to examine the influence of a single factor while controlling for other variables. The final models were assessed by pseudo R square, area under the Receiver Operating Characteristic (ROC) curve and Hosmer-Lemeshow goodness-of-fit test (for 10 groups).

6. RESULTS

Overall, 394 isolated CABG procedures were performed at NMMC from January 1, 2003 to December 31, 2003. Three cases were excluded from the analyses because of incomplete data (missing data exceeded 50% of the entire pool). Finally, the study included 391 cases of isolated CABG.

6.1. Patient preoperative profile

Patient perioperative profile was described through obtaining frequencies for categorical data (Table 1) and means and standard deviations for continuous data (Table 2).

Table 1. Preoperative profile of patients (categorical variables)

Characteristics	Frequency (%) (n=391)
Male	87.7
History of MI	60.1
Acute MI in admission diagnose	17.9
No sinus rhythm	3.8
Previous cardiac surgery	2.6
Drug allergy	13.7
Hypertension	77.7
Diabetes mellitus	16.6
Cerebrovascular accident	2.6
COPD	2.0
Extracardiac arteriopathy	2.8
Urogenital disease	4.1
Renal disease	6.9
Gastrointestinal disease	18.4
Other disease*	10.5
Number of diseased coronary vessels	7.5
One	30.2
Two	62.3
Three	
Left main stem disease	8.2
Ejection Fraction	
Good (>=50%)	59.9
Fair (30-49 %)	38.8
Poor (< 30%)	1.3
Priority of operation	
Elective	68.3
Urgent	31.7

*Other diseases included different types of hernia (n=14), osteochondrosis (n=9), podagra (n=2), hemorrhoid (n=2), etc.

More than two-thirds of the patients were male (87.7%). About 60% of patients had history of myocardial infarction with 17.9% having had an acute MI. Among comorbid conditions, the most prevalent were hypertension (78%) followed by gastrointestinal diseases (18.4%) and diabetes mellitus (16.6%). From 27 patients with renal disease, only 3 had a history of

renal failure, while others had nephrolithiasis, pyelonephritis, etc. About 90% of patients had more than one narrowed coronary vessel. Left main stem disease was experienced by 32% of patient population. Only 1.3 % of patients had poor (less than 30%) ejection fraction (EF).

Table 2. Preoperative profile of patients (continuous variables)

Characteristics	Mean (sd)
Age	55.3 (9.46)
BMI	29.3 (4.31)
BSA	1.94 (0.16)
EuroSCORE	2.34 (1.82)

The mean age of patients was 55.3 years with the range from 28 to 80 years (sd=9.5). Patients aged more than 60 years accounted for 5.4% of study population (n=21). Mean Body mass index (BMI) was 29.3 and mean Body surface area (BSA) was 1.94.

The mean EuroSCORE or the predicted mortality rate of the population based on the preoperative characteristics was 2.34 while the observed crude inhospital mortality was 2.05% (n=8). While the O/E rate or Standardized mortality rate was less than 1, no significant difference was found between observed and expected hospital mortality rates (p=0.78).

Some of variables were excluded from the analyses because of missing data in more than 10% of cases (smoking history, other than drug allergy, family history of hypertension, ischaemic hearth disease or sudden cardiac death, physical activity, hypercholesterolemia), while could be important predictors of CABG outcome (Table 3).

Table 3. Variables excluded from the study

Variable	Frequency (%) of missing values	Valid 'Yes' (excluding missing values)
Smoking history	24%	82.2%
Other than drug allergy	27.1%	7%
Family history of hypertension, IHD or sudden cardiac death	51.7%	61.9%
Physical activity (active, moderate or sedentary)	32.5 %	Not applicable
Hypercholesterolemia	39.9%	58.7%

The variable indicating the family history of cardiovascular disease had the highest rate of missing data (51.7%). Patient physical activity assessed as active, moderate or sedentary was also excluded from the study because of missing values in 32.5% of SEFs.

Of all patients, 238 (62.8%) onderwent isolated CABG procedure with cardiopulmonary bypass (CPB). The mean CPB time was 121 minutes (sd = 39.2) and the mean aortal clump time was 42.8 minutes (sd=15.9).

6.2. CABG associated hospital morbidity

CABG associated hospital morbidity was analyzed both as any morbid event and as serious morbidity. Overall, 29.2% of the study population experienced any morbid event. This

includes a variety of complications from mild (ex. left forearm radial seroma) to severe (mediastinitis, renal failure) (Table 4).

Table 4. Isolated CABG associated hospital morbidity

In hospital Morbidity	Frequency (%) (n=391)
Postoperative arrhythmia	17.6
Pleural/pericardial effusion & tap	7.4
Respiratory complications*	2.1
Wound infection	1.8
Left diaphragmal paralysis	1.5
Sternal dehiscence	1.02
Renal failure/dyalisis	0.77
Mediastinitis	0.5
Cerebrovascular event	0.5
Left forearm radial seroma	0.5
PostCABG stenocardia	0.5
Reexploration	0.26
Pneumothorax	0.26
Hemorrhoidal bleeding	0.26
Cholecistectomia	0.26
Dignostic laparotomia	0.26
Neiropathy of nervus facialis	0.26
Induartion and pain in mammarian gland	0.26

** Respiratory complications (n=8) included respiratory failure requiring CPAP (2) or requiring tracheostomy (2), pneumonia (1) and Acute Respiratory Distress Syndrome (3)*

Postoperative arrhythmia was the highest frequent (17.6%) postoperative complication (all patients with preoperative arrhythmias were excluded from having it postoperatively). Patients with postoperative arrhythmias had both significantly higher mean length of hospital stay (11.5 versus 14.6 days) and length of postoperative stay (10 versus 13 days) than others (p=0.001 for both). Of these patients, about 65% had paroxysms of atrial fibrillation. About 7.4% of patients had pleural/pericardial effusion after the operation. None of these complications was considered as life threatening for patients. Other complications had low incidence from 0.26% to 1.8%. No patient had cardiac bleeding requiring reoperation or any other CABG associated reoperation. Only one patient underwent a reexploration of the surgical wound because of mediastinitis.

For the next step, a summary variable of **serious hospital morbidity** was created. It included the patients who experienced at least one of the following complications: wound infection, mediastinitis, cerebrovascular event (TIA/ stroke), renal failure/dialysis, respiratory complications (excluding 2 cases of respiratory failure resulting in CPAP), and hospital death. The total number of patients who experienced a serious morbid event was 23 (5.9%). Univariate logistic regression analyses identified the predictors of severe hospital morbid event (Table 5).

Variables such as no sinus rhythm, drug allergy, diabetes mellitus, left main stem disease and the priority of operation were significantly associated with the outcome. Nevertheless, the large confidence intervals of some variables (no sinus rhythm, previous cardiac surgery,

COPD, diabetes mellitus, cerebrovascular events, ejection fraction, etc) indicated that larger sample size was needed for more precise estimation of associations.

Overall, the patients with severe morbid events had significantly higher EuroSCORE than others (OR=1.38; CI: 1.16-1.65; p< 0.001) indicating that prior the admission they had higher probability of early mortality after CABG procedure. In the group of patients with severe morbid event the mean EuroSCORE was about twice as much as in patients without such events (4.23 versus 2.22).

Table 5. Univariable analyses of serious hospital morbidity predictors

Predictor variables	Odds ratio	CI	P-value
Age	1.04	0.99 - 1.09	0.071
Female	2.10	0.74 - 5.94	0.162
History of MI	0.71	0.30 - 1.65	0.425
Acute MI	2.12	0.84 - 5.36	0.113
No sinus rhythm	4.45	1.16 - 17.04	0.029†
Previous cardiac surgery	4.29	0.86 - 21.46	0.077
BMI	1.04	0.95 - 1.15	0.380
BSA	0.54	0.05 - 7.28	0.644
Drug allergy	3.04	1.19 - 7.83	0.021†
Hypertension	1.38	0.46 - 4.18	0.565
Diabetes mellitus	4.38	1.83 - 10.48	0.001†
Cerebrovascular accident	1.81	0.22 - 14.96	0.580
COPD	2.34	0.28 - 19.91	0.435
Extracardiac arteriopathy	1.62	0.19 - 13.25	0.651
Urogenital disease*	-	-	-
Renal disease	2.15	0.59 - 7.75	0.242
Gastrointestinal disease	1.61	0.62 - 4.26	0.332
Other diseases	0.37	0.05 - 2.85	0.341
Number of diseased coronary vessels			
One**	0.99	0.11 - 9.22	0.994
Two	2.26	0.29 - 17.59	0.436
Three			
Left main stem disease	3.51	1.21 - 10.20	0.021†
Ejection Fraction			
Good (>=50%)*			
Fair (30-49 %)	1.43	0.59 - 3.46	0.426
Poor (< 30%)	13.45	2.04 - 88.96	0.007†
CPB	1.11	0.46 - 2.69	0.814
CPB time	1.01	0.99 - 1.03	0.159
Ao clump time	0.98	0.93 - 1.04	0.528
Priority of operation			
Elective*			
Urgent	2.49	1.07 - 5.82	0.035†
EuroSCORE	1.38	1.16 – 1.65	0.000

** None of the 16 patients with urogenital disease had any serious morbid event*
*** Reference population*
†Statistically significant result (p< 0.05)

Finally, in order to examine the effect of an individual variable while controlling for the others, multiple logistic regression analyses were conducted using forward stepwise selection method. The criterion to enter into the model was *p* value of 0.25 maximum and the criterion to remain in the model was *p* value of no more than 0.05 (10). The final model was checked for potential confounders and interactions (Table 6).

Table 6. Final model: Severe morbid event

Covariates	**OR**	***p* value**	**CI**
Previous cardiac surgery	8.30	0.018	1.43 - 48.10
Drug allergy	3.93	0.010	1.38 - 11.11
Ejection fraction			
Good (>=50%)*			
Fair (30-49 %)	1.62	0.319	0.63 - 4.18
Poor (< 30%)	19.51	0.005	2.46 - 54.70
Diabetes	4.36	0.002	1.69 - 11.23
Left main stem disease	5.12	0.008	1.54 - 17.05
Area under the ROC curve		**0.796**	
H-L goodness-of-fit test (p value)		**0.818**	
Pseudo R^2		**0.170**	

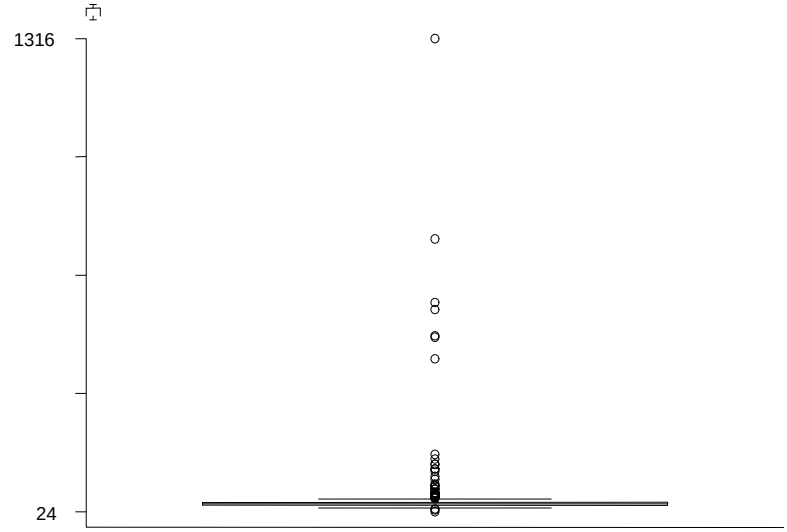
** Reference population*

Based on the model, patients with previous cardiac surgery had higher risk to develop a severe morbid event (OR=8.3) when controlling for drug allergy, EF, diabetes and left main stem disease. Although patients with poor EF had significantly higher probability of developing severe morbid event as compared to patients with good EF, the large CI indicated that a larger sample size was needed for more accurate estimation. The odds of severe morbidity was 4.36 times higher for diabetics than for others adjusting for previous cardiac surgery, drug allergy, EF and left main stem disease. For this patient population, left main stem disease was also independently and significantly associated with the outcome (OR=5.12). The final model had high validity with acceptable calibration and discrimination. On the other hand, these 5 variables explained only 17% of the outcome indicating that there were other variables that should be examined or a larger sample size was needed to detect the association between the collected variables and the occurrence of severe morbid event.

6.3. Prolonged ICU stay and the predictors

Mean ICU length of stay was 61.5 hours with a range from 24 to 1316 hours (sd=94.95). It would be wrong to assess ICU length of stay as a normally distributed continuous variable, because some of the patients with long ICU stay would have a profound effect on the mean value. The box plot of ICU stay showed the spread of the values and the existence of many influential outliers (Figure 1). Of all patients 72.7 % (n=275) had ICU length of stay less than or equal to 48 hours.

Figure 1. Length of ICU stay (hours)



As an alternative for continuous variable (as it was defined in many other studies), a new variable of prolonged ICU stay was created. **The prolonged ICU stay** was a dichotomous variable with two categories: ICU stay less than 3 days (72 hours) and ICU stay more than or equal to 3 days. Of all 391 patients who underwent isolated CABG procedure during 2003, 9.5 % (n=37) had prolonged ICU stay. The crude in-hospital mortality of this group was 16.2% (6 patients). In-hospital mortality of patients who had ICU length of stay < 3 days was 0.56% (2 patients). The difference between the groups with respect to hospital mortality was statistically highly significant ($p<0.001$). The mean EuroSCORE was significantly different between the groups of patients with ICU stay >=3 days versus <3 days ($p=0.002$) indicating that patients with prolonged ICU stay had more severe condition and had higher probability of early operative mortality than other patients prior to surgery. The contingency table of prolonged ICU stay versus severe morbidity indicated that 43% of patients with prolonged ICU stay experienced a severe morbid event during their current admission for CABG procedure (probability of chi-square statistics was less than 0.001).

In order to identify the predictors of prolonged ICU stay, a univariable logistic regression analyses were performed. Results were presented in Table 7.

Table 7. Simple logistic regression of ICU length of stay by different predictors

Predictor variables	Odds ratio	Confidence Intervals	P-value
Age	1.06	1.02 - 1.10	0.003†
Female	2.60	1.14 - 5.90	0.023†
History of MI	0.53	0.27 - 1.05	0.068
Acute MI	1.30	0.57 - 2.98	0.536
No sinus rhythm	7.42	2.48 - 22.21	0.000†
Previous cardiac surgery	7.03	1.89 - 26.17	0.004†
BMI	1.02	0.94 - 1.10	0.593
BSA	0.28	0.03 - 2.38	0.246

Predictor variables	Odds ratio	Confidence Intervals	P-value
Drug allergy	1.34	0.53 - 3.42	0.537
Hypertension	2.53	0.87 - 7.34	0.088
Diabetes mellitus	2.01	0.92 - 4.39	0.079
Cerebrovascular accident**			
COPD	3.31	0.64 - 17.04	0.152
Extracardiac arteriopathy	0.98	0.12 - 7.91	0.987
Urogenital disease	0.63	0.08 - 4.89	0.657
Renal disease	2.36	0.84 - 6.65	0.105
Gastrointestinal disease	1.25	0.55 - 2.86	0.597
Other diseases	1.04	0.35 - 3.09	0.946
Number of diseased coronary vessels			
One*			
Two	2.33	0.28 - 19.19	0.431
Three	3.53	0.46 - 27.02	0.224
Left main stem disease	1.89	0.68 - 5.25	0.221
Ejection Fraction			
Good (>=50%)*			
Fair (30-49 %)	1.83	0.92 - 3.64	0.086
Poor (< 30%)	3.18	0.34 - 30.02	0.313
CBP	1.10	0.54 - 2.23	0.796
CBP time	1.003	0.99 - 1.01	0.626
Ao clump time	0.99	0.96 - 1.03	0.811
Priority of operation			
Elective*			
Urgent	1.55	0.77 - 3.10	0.218

** Reference population*

*** None of the 10 patients with prior cerebrovascular accident had prolonged ICU stay*

† Statistically significant result (p< 0.05)

Statistically significant odds ratios were identified for age, gender, no sinus rhythm, and previous cardiac surgery. In the next step, forward stepwise selection method was used to conduct multivariable logistic regression analyses. *P* value of 0.25 maximum was the criterion to enter into the model and at least 0.05 to remain in the model (10). Potential confounders and interactions of the variables included in the model were also examined. Selected final models were presented in the Table 8.

Table 8. Final model: Prolonged ICU stay

Covariates	**Model 1**			**Model 2**		
	OR	***p* value**	**CI**	**OR**	***p* value**	**CI**
Age	1.06	0.008	1.01 - 1.10	1.05	0.020	1.01-1.09
No sinus rhythm	6.08	0.002	1.93 - 19.10	7.99	0.001	2.4-26.5
Previous cardiac operation	6.92	0.007	1.70 - 28.22	7.72	0.005	1.88-31.6
Hypertension				3.24	0.061	0.95-11.10
Area under the ROC curve	**0.730**			**0.710**		
H-L goodness-of-fit test (p value)	**0.928**			**0.596**		
Pseudo R^2	**0.098**			**0.116**		

Both models had acceptable discrimination (area under the ROC curve from 0.7 to 0.8) and not significant Hosmer-Lemeshow goodness-of-fit test results ($p>0.05$). Nevertheless, they explained only about 1/10 of the prolonged ICU stay. An important factor in model selection is the inclusion of clinically relevant variables. This approach favored Model 2 where the history of hypertension although borderline significant was included in the model as an important predictor of prolonged ICU stay. The likelihood ratio test comparing two models resulted in a significant *p*-value (0.036) approving the selection of the more saturated Model 2.

Based on the Model 2, with one year increase in age the odds of prolonged ICU stay increases by 1.06 controlling for cardiac rhythm, hypertension and prior cardiac operation. The odds of prolonged ICU stay was about 8 times higher in the group of patients with no sinus rhythm prior operation vs. patients with sinus rhythm adjusting for other variables of Model 2. Patients with prior cardiac operation were more likely to have prolonged ICU stay than others (OR=7.715). The odd of outcome was about 3 times higher for patients with the history of hypertension compared with normotensives.

7. DISCUSSION

Morbidity reports for CABG procedures may provide valuable insights on areas that need to be focused to improve quality of care. Based on the findings of this research, the most prevalent morbidity was caused by postoperative arrhythmias. In 2000, a small randomized clinical trial (n=189) was conducted at NMMC to evaluate the preventive effect of preoperative digoxin administration on postoperative arrhythmias. The results showed no preventive effect of preoperative digoxin therapy. The present study underlined the importance of conducting new interventional studies related to CABG postoperative arrhythmias. Although in most cases the postoperative arrhythmias were not life threatening and many patients were discharged with sinus rhythm, the study revealed that these patients had significantly longer length of postoperative and hospital stay than others and, thus, higher treatment associated costs.

Among severe morbidity, there were 6 cases (1.5%) of serious respiratory complications such as respiratory failure requiring tracheostomy, pneumonia and ARDS. Unfortunately, there were no data on ventilation time to evaluate its role on these complications. Routinely recorded intubation time is not a full indicator of the ventilation time. Other complications such as renal failure, wound infection, mediastinitis, and cerebrovascular accident had low rates and felt in the range of other reported results (1,6,7).

Overall, the multivariable analyses of severe morbid event (included mortality) revealed 5 significant predictors: previous cardiac surgery, drug allergy, EF, diabetes and left main stem disease. Drug allergy was a surprising finding as a predictor of severe morbidity. On the other hand, it could be assumed that such patients had other comorbid condition along with the drug allergy. The remaining predictors were identified as predictors of serious morbidity and mortality in other observational studies as well (1,6,7).

Patient preoperative factors played an essential role in the surgical outcome such as mortality and morbidity. Nevertheless, the patient prognosis at the arrival to the ICU may differ from the preoperative prognosis (W). Along with preoperative factors, other factors such as blood gases, hearth rate and cardiac index at the time of ICU admission, use of Intra-aortic balloon

pump (IABP) during the operation, ventilation time at ICU could also play important roles (W). Unfortunately, for this study, only data on patient preoperative status was collected along with the data about CPB time. In univariable logistic regression analyses of prolonged ICU stay, 8 preoperative variables had ORs with *p* values less than 0.10. The final model developed by multivariable analyses included 4 variables independently associated with the outcome: age, no sinus rhythm, previous cardiac operation and hypertension. The large CI of some variables indicated that larger sample size is needed for more accurate conclusion. However, the study aimed to find the possible predictors of prolonged ICU stay rather than to develop a model, which would be used afterward for exact prediction of this outcome.

Identification of patients who would probably have higher ICU length of stay is a valuable tool for appropriate resource allocation within the hospital. Based on the results of this study, patients with the identified predictors would more likely have prolonged ICU stay than others. An interesting result is the difference in predictors of two quality indicators as severe morbidity and prolonged ICU stay. The only common predictor of these outcomes was previous cardiac operation. These patients should be considered as serious even prior surgery. A larger sample size, however, would be more powerful in assessing other predictors.

8. CONCLUSIONS

Based on the results it could be concluded that the rates of hospital mortality, morbidity and prolonged ICU stay of patients who underwent isolated CABG surgery at NMMC in 2003 were not high and were comparable with the results from other cardio surgical centers. Significant independent predictors of serious morbidity were previous cardiac surgery, drug allergy, poor EF, diabetes and left main stem disease. The predictors of prolonged ICU stay included age, no sinus rhythm, previous cardiac operation and hypertension. Older patients and patients with identified predictors should be managed more cautiously both in terms of possible negative outcomes and treatment associated costs. The obtained data on these quality indicators will be used as a baseline level for further self-assessment activities and could become a benchmark for other cardio surgical centers in Armenia (if established).

Another recently conducted study validated EuroSCORE model ability to predict early mortality of patents undergoing isolated CABG procedure. The present study indicated that along with predicting early mortality risk of a patient, this model allows to differentiate the patients with high risk for having severe morbid event and prolonged ICU stay after isolated CABG procedure.

Further research with larger sample size would allow developing specific models to calculate the risk of having prolonged ICU stay and/or serious morbid event and would enhance to plan further medical care of patients. The current study results will be used for sample size calculations and different comparisons.

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Appendix 1. Definitions of study variables

Variable	Definition of the variable
Preoperative characteristics	
Age	Age of he patient at the time of surgery
Gender	Gender of the patient
History of MI	History of MI prior surgery
Acute MI	Acute MI in the admission diagnose
No sinus rhythm	The presence of sinus rhythm disturbance prior surgery
Previous cardiac surgery	Cardiac surgery in the past
Drug allergy	History of drug allergy
BMI	Formula of calculation: Weight (kg) /Height^2 (m)
BSA	Formula of calculation: (7.184^10-3) x (mass^0.425) x (height^0.725)
Smoking history	Present or past history of smoking
Drug allergy	History of drug allergy
Diabetes mellitus	The presence of oral / insulin / diet controlled diabetes
Cerebrovascular accident	A history of cerebrovascular accident (stroke/TIA)
COPD	A history of chronic obstructive respiratory disease (bronchitis, asthma)
Extracardiac arteriopathy	Included claudication, carotid occlusion or >50% stenosis, previous or planned intervention on the abdominal aorta, limb arteries or carotids
Hypertension	Patient is using a medication or had high blood pressure prior surgery
Urogenital diseases	A history of urogenital disease (ex. prostatitis, urine bladder stones)
Gastrointestinal diseases	A history of gastrointestinal diseases (gastritis, ulcers, neoplasm)
Renal disease	A history of renal disease (acute or chronic renal failure, dialysis, nephrolithiasis, pyelonephritis, creatinine >200 umol l-1 at the time of surgery, etc)
Hypercholersterolemia	A history of hypercholersterolemia prior surgery or after surgery within a month (if total blood cholesterol is above the level of 5.7mmol/L)
Number of diseased coronary vessels	The number of major coronary vessel systems (left anterior descending, left circumflex, right coronary) with > 50% narrowing in any angiographic view (left main disease is counted as two vessels)
Left main stem disease	If there is > 50% compromise of left main vessel diameter
EF	Ejection fraction measured by echocardiography or by ventriculography:

Variable	Definition of the variable
	good (>=50%); fair (30-49 %); poor (< 30%)
Priority of operation (defined as in UK Bayes model) (11)	*Elective:* routine admission from the waiting list; procedure may be deferred without risk, *Urgent* (included also emergent and salvage): not scheduled for routine admission from the list but require surgery on the current admission for medical reasons; they cannot be sent home without surgery, (worsening, sudden chest pain, CHF, AMI, unstable angina or rest angina); unscheduled with ongoing refractory cardiac symptoms; there should be no delay in surgical intervention irrespective of the time of day (pulmonary edema, carcinogenic shock); requiring CPR en route to theatre or prior to anaesthetic; CPR following anaesthesia should not be included
Variables related to operation	
CPB	If CPB was used during the present CABG procedure
CPB time	The total of all bypass runs if a second or subsequent period of bypass was conducted (minutes).
Ao clump time	Total number of minutes the aorta was completely cross-clamped during bypass
Outcome variables and postoperative complications	
Hospital mortality	Death occurred during the current admission and causally related to present operation
Hospital morbidity	Any complication occurred during the hospitalization for surgery
ICU length of stay	Total ICU length of stay if a second or more ICU admission occurred after the operation during the current admission
Postoperative arrhythmia	Arrhythmia occurred during postoperative stay (atrial/ventricular fibrillation, AV block, extrasystole, etc)
Wound infection	Must have wound disruption of any magnitude with positive culture
Mediastinitis	Culture positive effusion or pass in the pericardium
Serious respiratory complications	Included respiratory failure with prolonged artificial ventilation and tracheostomy; pneumonia diagnosed by clinical findings and para clinical diagnostic tests such as positive cultures of sputum, chest X-ray, blood gas analyses, etc.; ARDS diagnosed by clinical signs and approved by blood gas analyses, chest X-ray, etc.
Cerebrovascular event	Either transient (< 24 hours) or permanent neurologic deficit occurred after the operation
Renal failure/dyalisis	Acute postoperative renal insufficiency resulting in one or more of the following: a. a new requirement for dialysis or institution of dyalisis b. increase of serum creatinine to above > 115 ìmol/L c. 50% or greater increase in creatinine or BUN over baseline preoperative value
Cardiac reoperation	Operative re-intervention required because of bleeding, coronary graft occlusion or for other cardiac reasons
Bleeding	Bleeding causally related to the current procedure and requiring reoperation
Other complications	Other complications included postCABG stenocardia, other than cardiac bleeding, other than cardiac

Variable	Definition of the variable
	reoperation, pneumothorax, sternal dehiscence, left diaphragmal paralysis, pleural and/or pericardial effusion & tap, etc.
ARDS=Acute Respiratory Distress Syndrome; BMI = Body Mass Index; BSA= Body Surface Area; CBP = Cardiopulmonary bypass; COPD=Chronic Obstructive Pulmonary disease; CPR=Cardiopulmonary Resuscitation; EF= Ejection fraction; ICU= Intensive Care Unit; MI = Myocardial infarction.	

Appendix 2. Study instrument

ID_ _ _

Name_____

1. Date of hospital admission _ _ / _ _ / _ _	**2. Date of discharge** _ _ / _ _ / _ _	**3. Date of surgery** _ _ / _ _ / _ _
4. Date of birth _ _ /_ _/ _ _	**5. Gender** 0. Male 1. Female	
6. Country of residency 1. Armenia 2. Georgia 3. Russia 4. Other	**7. Diagnosis at admission to ACC** 1. IHD 5. CHD 9. Other 2. HVD/rheumatic 6. Arrhythmia 3. HVD/non rheumatic 7. Cardiomyopathy 4. Hypertension 8. MI_____	
8. IHD 1. Stable angina **2. Unstable angina (CCS)**		**9. Cong. Heart Failure (NYHA)** 0. No 1. Yes
10. History of Miocardial infarction 0. No 1. Yes	**11. Cardiogenic shock** 0. No 1. Yes **11_1.** 1. Hemod.instability 2. Refractrory shock	**12. Arrhythmia** 0. No 1. Yes 1. Sust. VT/VF 3. AFib/Flutter 2. Heart block
13. Previous cardiac intervention (besides the last one) 0. No 1. Yes #____	**14. Previous cardiac surgery** 0. No 1. Yes #_____	**15. a. Weight_____ b.Height _____** **16. BMI** _____ kg/m^2 **17. BSA** _____ m^2
18. Smoking status a. Present 0. No 1. Yes b. Past 0. No 1. Yes	**19. Physical activity** 1. Active 2. Moderate 3. Sedentary	**20. Drug allergy** 0. No 1. Yes **21. Other allergy** 0. No 1. Yes
22. Family history of IHD, SCD, or hypertension 0. No 1. Yes	**23. Diabetes mellitus** 0. No 1. Yes **23_1. Type of control** 1. Oral 2. Insulin 3. None 4. Diet	
24. Cerebrovascular accident 0. No 1. Yes	**25. Respiratory disease** 0. No 1. Yes	**26. Extracardiac arteriopathy** 0. No 1. Yes
27. Infectious endocarditis 0. No 1. Yes **27-1.** 1. Treated 2. Active	**28. Hypercholesterolemia (Chol. > 5.7mmol/L)** 0. No 1. Yes	**29. Hypertension** 0. No 1. Yes

30. Urogenital diseases 0. No 1. Yes	**31. Renal diseases** 0. No 1. Yes	**32. Preoperative creatinine (>200ì mol/L)** 0. No 1. Yes
33. Gastrointestinal diseases 0. No 1. Yes	**34. Other diseases** 0. No 1. Yes **34_a.** _____	**35. Priority of operation** 1. Elective 2. Urgent 3. Emergent
36. Number of diseased coronary vessels 1. None 2. Two 3. One 4. Three	**37. Left main disease** (>50% stenosis) 0. No 1. Yes	**38. Ejection fraction** _____% 1. Good (>=50%) 2. Fair (30-49%) 3. Poor (<30%)
39. Postinfarct Septal Rupture 0. No 1. Yes	**40. CPB** 0. No 1. Yes	**41. IABP** 0. No 1. Yes
42. Length of ICU stay (hours) _____	**43. 30 day postoperative status** 1. Dead 0. Alive	**44. Postoperative (inhospital) complications** 0. No 1. Yes

Postoperative (inhospital) complications

45. Bleeding	No Yes	
46. Arrhythmia	No Yes	
47. Wound infection	No Yes	
48. Pneumonia	No Yes	
49. Stroke/TIA	No Yes	
50. MI	No Yes	
51. Reoperation	No Yes	
52. Other	No Yes	
52_a. Specify other_____		

53. Predicted death rate **a. UK Bayes Simple** _____ % **b.UK Bayes Complex** _____ % **c. EuroSCORE** _____ %