Outcomes of Early Extubation After Bypass Surgery in the Elderly

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Background. While early extubation after coronary artery bypass grafting (CABG) has been associated with resource savings, its effect on patient outcomes remains unclear. The goal of the present investigation was to evaluate whether early extubation can be performed safely in elderly CABG patients in community practice.

Methods. We studied 6,446 CABG patients, aged 65 years and older, treated at 35 hospitals between 1995 and 1998. Patients were categorized based on their post-CABG extubation duration (early, < 6 hours; intermediate, 6 to < 12 hours; and late, 12 to 24 hours). We compared unadjusted and risk-adjusted mortality, reintubation rates, and post-CABG length of stay (pLOS). We also examined the association between patients' intubation time and outcomes among patients with similar propensity for early extubation and among high-risk patient subgroups.

Results. The overall mean post-CABG intubation time was 9.8 (SD 5.7) hours with 29% of patients extubated within 6 hours. After adjusting for preoperative risk factors patients extubated in less than 6 hours had significantly shorter postoperative hospital stays than those with later extubation times. Patients extubated early also tended to have equal or better risk-adjusted mortality than those with intermediate (odds ratio: 1.69, p = 0.08) or long intubation times (odds ratio: 1.97, p = 0.02). These results were consistent among patients with similar preoperative propensity for early extubation and among important high-risk patient subgroups. There was no evidence for higher reintubation rates among elderly patients selected for early extubation.

Conclusions. In community practice, early extubation after CABG can be achieved safely in selected elderly patients. This practice was associated with shorter hospital stays without adverse impact on postoperative outcomes.

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The profile of patients undergoing coronary artery bypass grafting (CABG) in North America is changing, with CABG patients becoming older and having more comorbid illness [1–3]. As a result CABG patients are at increasing risk for postoperative complications and resultant higher procedural costs [4]. One strategy proposed to limit CABG resource utilization has been the development of fast track algorithms for early post-CABG extubation. These care algorithms generally employ less sedation and standardized postoperative care maps to achieve extubation within 6 hours after surgery [5, 6].

In most but not all studies early extubation has been associated with decreased resource use owing to shorter intensive care unit and overall postoperative hospital stays [6–13]. These prior evaluations however have concentrated on younger, healthy patient populations and were often performed at large specialized centers. Moreover these studies have not been sufficiently sized to adequately assess the safety of early extubation [10, 14–18]. Some clinicians have voiced concerns that early extubation might lead to increased rate of reintubation. Others have feared that the low use of analgesic medications and sedation could actually increase the risk for perioperative adverse events particularly among elderly or high-risk patients [14, 16].

The objectives of the present investigation were to assess the use and outcomes of early extubation among 35 diverse community hospitals. Within this setting, we sought to determine the degree to which early extubation can be performed safely in elderly CABG patients as well as to examine its impact among those with important comorbid illness.

Patients and Methods

Data Source

This analysis is based on the patient population from the Alabama Cooperative CABG project, which has been described in detail elsewhere [19, 20]. Briefly this quality improvement project was conducted by the Alabama Quality Assurance Foundation (AQAF), a Medicare

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Quality Improvement Organization designated and funded by the Centers for Medicare and Medicaid Services (CMS), formerly the Health Care Financing Administration, to carry out statewide quality improvement initiatives. The project examined care and outcomes of bypass surgery during an initial study period (July 1, 1995, through June 30, 1996) and compared these with cases performed after a quality improvement initiative (July 1, 1998, through December 31, 1998). The study hospitals were located both in Alabama and a comparison state in which no interventions were performed. These analyses were completed after acquiring a waiver of consent from the Duke Institutional Review Board.

Patient Population

The project included patients aged 65 years or older undergoing CABG. Patients were initially identified through Medicare claims for CABG surgery (*International Classification of Diseases, 9th Revision, Clinical Modification* [ICD-9 CM] [21] codes 36.10 to 36.20, excluding diagnosis-related groups 104, 105, and 468). After identification, the patients' clinical data were collected through retrospective chart abstraction by independent, trained clinical personnel from the Clinical Data Abstraction Center (CDAC) of the Health Care Financing Administration. For quality control purposes, 20% of these charts were periodically reabstracted. The dataset used in the present analysis was very complete with all major variables except ejection fraction (12.5%) and blood urea nitrogen (8.5%) missing in less than 2% of patients.

For the current analysis we included those patients undergoing isolated bypass surgery and excluded patients with missing extubation time (n = 680) and those intubated for greater than 24 hours (n = 737). This latter exclusion was done so as to concentrate on patients with elective extubation times, conservatively assuming that many patients intubated for more than 24 hours after surgery may have had a complicated postoperative course.

Key Variables and Definitions

Post-CABG intubation time was defined as the time interval between the end of surgery and the time when mechanical ventilator support was discontinued. While time to extubation was considered as a continuous variable in our adjusted analysis, we also categorized post-CABG intubation time for display purposes into three mutually exclusive groups: less than 6 hours (short intubation times); 6 to less than 12 hours (intermediate intubation times); and 12 to 24 hours (extended intubation times). The main outcomes under investigation were postoperative length of hospital stay (pLOS), all-cause in-hospital mortality, and rate of reintubation.

Statistics

Descriptive statistics for patients are provided by different intubation time categories. Continuous variables were summarized using means and standard deviations while categorical variables were summarized by percentages. Comparisons among groups were conducted using nonparametric tests. Kruskall-Wallis and χ^2 tests were used for comparisons among continuous and categorical variables respectively.

As extubation times were not randomized we adjusted our analyses for the preoperative risk of the patients. Specifically risk scores for in-hospital mortality, and rate of reintubation were calculated using logistic regression models. These models contained preoperative clinical variables known to be associated with adverse outcomes in prior analyses [19, 20]. Similar risk scores for pLOS were constructed using linear regression. The risk-adjusted effect of intubation time was calculated using generalized estimating equations including the estimated risk score, indicator variables for the state, year, and intubation time group [22, 23]. The generalized estimating equations accounted for clustering within site. Intubation time less than 6 hours was used as the reference group. Similar adjusted analyses were performed on patient subgroups including analyses by age (<75 years versus ≥75 years), sex, presence of chronic obstructive pulmonary disease (COPD), and history of myocardial infarction (MI) within 14 days of the CABG. Within each intubation time group, risk-adjusted pLOS was calculated by taking the ratio of the observed and expected values and multiplying by the sample mean.

We also used matched propensity score analysis as a second method of adjusting for potential baseline confounding variables [24]. Propensity score matching reduces all patient and hospital-level baseline characteristics to a single composite score that summarizes all potential confounding factors and has been described as the more reliable risk-adjustment method than multivariable analyses [24]. Briefly we first identified baseline patient and hospital features associated with a patient's likelihood for early discharge using logistic regression. We then matched patients who were extubated within 6 hours with a patient with a similar estimated propensity for early extubation but who was extubated between 6 and 12 hours. After matching we again compared baseline risk profiles of the two groups to assure that no major difference in baseline patients characteristics existed and then compared outcomes (pLOS, mortality rates, and reintubation rates).

We tested all predictor variables in Table 1 for their univariate association with reintubation. All variables with p less than 0.10 were considered as candidates for the final model which included continuous patient-level intubation time and all variables significantly associated with reintubation at the level of statistical significance ($p < 0.05$) after stepwise backward elimination. The final model was examined to calibration and discrimination. All computations were performed using SAS version 8.2 (SAS Institute, Cary, NC). All tests of statistical hypotheses were conducted at the two-tailed 0.05 level of statistical significance.

Results

Patient Characteristics and Unadjusted Outcomes

A total of 6,446 patients were included in the present analysis. The overall mean post-CABG intubation time

Table 1. Patients' Baseline Characteristics by Patient Level Intubation Time

	Overall n = 6,446	0–<6 Hours n = 1,870	6–<12 Hours n = 2,618	12–≤24 Hours n = 1,958	*p* Value
Age in years, mean (SD)	72.3 (5.2)	71.8 (5.1)	72.2 (5.0)	72.9 (5.4)	<0.001
Female sex	35.3%	29.9%	36.4%	38.9%	<0.001
Race					
Black	5.3%	3.6%	5.5%	6.6%	<0.001
White	92.6%	94.2%	92.3%	91.4%	0.004
Other	2.2%	2.2%	2.3%	2.0%	0.807
Coronary artery disease					
History of MI	51.3%	47.4%	51.8%	54.5%	<0.001
MI on the day of CABG	1.4%	0.9%	1.4%	1.8%	0.049
MI within 14 days prior to the CABG	21.2%	19.0%	20.7%	24.0%	<0.001
Angina within 2 weeks prior to CABG	68.1%	63.5%	68.9%	71.5%	<0.001
Prior CABG	10.3%	9.7%	9.2%	12.3%	0.002
PTCA performed during this admission	2.0%	1.5%	2.3%	1.9%	0.141
Left main stenosis ≥ 50%	22.5%	21.2%	22.5%	23.6%	0.199
Function					
Ejection fraction, mean (SD)	49.1% (13.9)	52.1% (13.1)	51.2% (13.7)	49.3% (14.6)	<0.001
Mitral insufficiency	7.8%	5.6%	7.8%	10.0%	<0.001
History of CHF within 2 weeks prior to CABG	14.5%	11.3%	13.4%	19.1%	<0.001
Emergent operation	1.5%	0.9%	1.8%	1.8%	0.032
Urgent operation	9.6%	7.3%	9.5%	11.8%	<0.001
Comorbidities					
COPD	23.9%	23.4%	21.9%	27.1%	<0.001
Dialysis	0.6%	0.5%	0.5%	0.8%	0.381
Blood urea nitrogen, mean (SD)	18.2 (8.3)	17.4 (7.7)	18.1 (7.8)	19.1 (9.2)	<0.001
Diabetes mellitus	27.1%	26.7%	27.3%	27.2%	0.888
Cerebrovascular accident	10.8%	9.9%	10.1%	12.6%	0.008
Peripheral vascular disease	34.8%	42.9%	30.7%	32.5%	<0.001
Current smoker	17.5%	16.6%	16.6%	19.4%	0.024

CABG = coronary artery bypass graft surgery; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; MI = myocardial infarction; PTCA = percutaneous transluminal coronary angioplasty.

was 9.8 (SD 5.7) hours (median, 8.5 hours; 25th percentile, 5.6 hours; 75th percentile, 13.5 hours). Twenty-nine percent of patients overall were extubated within 6 hours after CABG surgery; 40.6% were extubated within 6 to 12 hours and 30.4% were extubated between 12 and 24 hours. The median post-CABG intubation time varied considerably among the hospitals ranging from 2.1 to 18.6 hours.

The patient population was predominantly white (92.6%), male (64.7%), with an average age of 72.3 (SD 5.2) years. A history of MI within 14 days of CABG surgery or COPD were present in 21.2% and 23.9% of all patients respectively. Most patient characteristics varied significantly among the different intubation time categories with better cardiac function and lower comorbidities in the early extubation subset (Table 1). Females, patients with MI within 14 days of CABG, patients with COPD, and elderly patients were less likely to undergo early extubation compared with males and younger patients without comorbidities (Table 1).

The overall postoperative length of stay was 8.1 (SD 9.7) days with the total length of stay 10.3 (SD 7.8) days. The overall mortality rate, reintubation rate, and ICU readmission rate were 2.0%, 3.9%, and 3.3% respectively (Table 2). Shorter post-CABG extubation times were significantly associated with better patient outcomes. The unadjusted pLOS was significantly shorter in the early (6.9 days, SD 3.1) versus the intermediate (7.7 days, SD 8.1) or late (9.7 days, SD 14.4) extubation subset ($p < 0.001$). The unadjusted mortality and reintubation rates were also lower in the early than in the intermediate or late extubation groups ($p < 0.001$ for both).

Table 2. Unadjusted Outcomes by Patient Level Intubation Time

	Overall n = 6,446	0–<6 Hours n = 1,870	6–<12 Hours n = 2,618	12–≤24 Hours n = 1,958	p Value
Postoperative length of hospital stay in days, mean (SD)	8.1 (9.7)	6.9 (3.1)	7.7 (8.1)	9.7 (14.4)	<0.001
Patient discharge within 5 days of coronary artery bypass graft surgery	20.2%	29.6%	21.1%	9.9%	<0.001
Mortality	2.0%	0.9%	1.8%	3.3%	<0.001
Reintubation	3.9%	2.8%	3.1%	6.0%	<0.001
Intensive care unit readmission	3.3%	2.5%	3.3%	4.0%	0.032

Risk-Adjusted Outcomes

After adjusting for baseline characteristics and comorbidities, early extubated patients had significantly shorter pLOS (7.1 days) versus those extubated between 6 and 12 (7.8 days, $p = 0.005$) and 12 and 24 hours (9.4 days, $p < 0.001$). In subgroup analyses, early extubated patients had consistently shorter pLOS than those extubated later regardless of patient gender and age group, and among those with and without COPD and recent MI (Fig 1).

Similarly risk-adjusted mortality tended to be equal or lower in early extubated patients compared with the intermediate (odds ratio [OR]: 1.69 versus early, 95% confidence interval [CI]: 0.96, 3.11; $p = 0.08$) and late extubation subset (OR: 1.97 versus early, 95% CI: 1.12, 3.63; $p = 0.02$). Early extubation was not associated with increased mortality among high-risk groups including those aged 75 years or older, women, and those with COPD (Fig 2).

The risk-adjusted rate of reintubation was significantly lower in early extubated patients compared with the late (12 to 24 hour) extubation subset (OR: 1.47 versus early, 95% CI: 1.02, 2.11; $p = 0.04$), while there was no difference between early and intermediate intubation groups (OR: 1.03 versus early, 95% CI: 0.76, 1.41; $p = 0.85$). Likewise, we could not identify any patient subgroups for which early extubation were associated with a higher risk for reintubation (Fig 3). In contrast Table 3 demonstrates that after risk-adjustment early extubation was actually associated with lower risk of reintubation. For every 6 hours longer in intubation time, a patient's risk of reintubation significantly increased (OR: 1.38 95% CI: 1.21; 1.57; $p < 0.001$). Other major predictors of reintubation included older age, increased blood urea nitrogen, MI on the day of the CABG, presence of COPD, peripheral arterial disease, mitral insufficiency, low ejection fraction, current smoking status, emergency operation, and "other" (nonwhite, non-black) race category.

Propensity Matching

Our propensity matching produced a total of 1,628 patient pairs (with 1 being extubated within 6 hours and the other being extubated between 6 and 12 hours). These

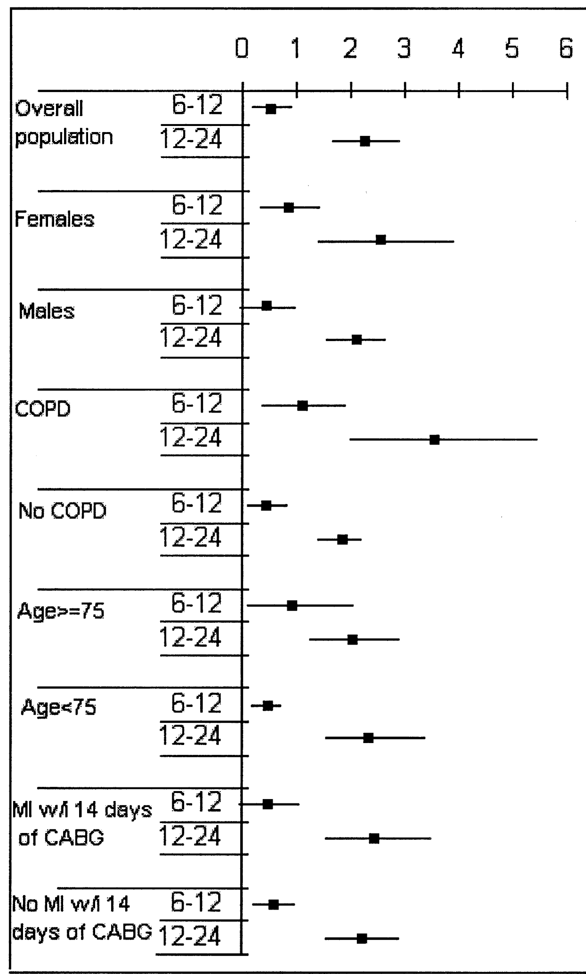

Fig 1. Risk-adjusted difference of length of stay in the overall populations and in stratified analyses. Reference category is early extubation group (0 to 6 hours). Squares *and* horizontal lines *indicate the point estimate and 95% confidence interval respectively. The* x-axis *indicates the difference in length of stay in days between the early (0 to 6 hours) and the intermediate (6 to 12 hours) and late (12 to 24 hours) intubation group. Positive differences in length of stay indicate an advantage of early extubation.* (CABG = *coronary artery bypass graft surgery;* COPD = *chronic obstructive pulmonary disease;* MI = *myocardial infarction.)*

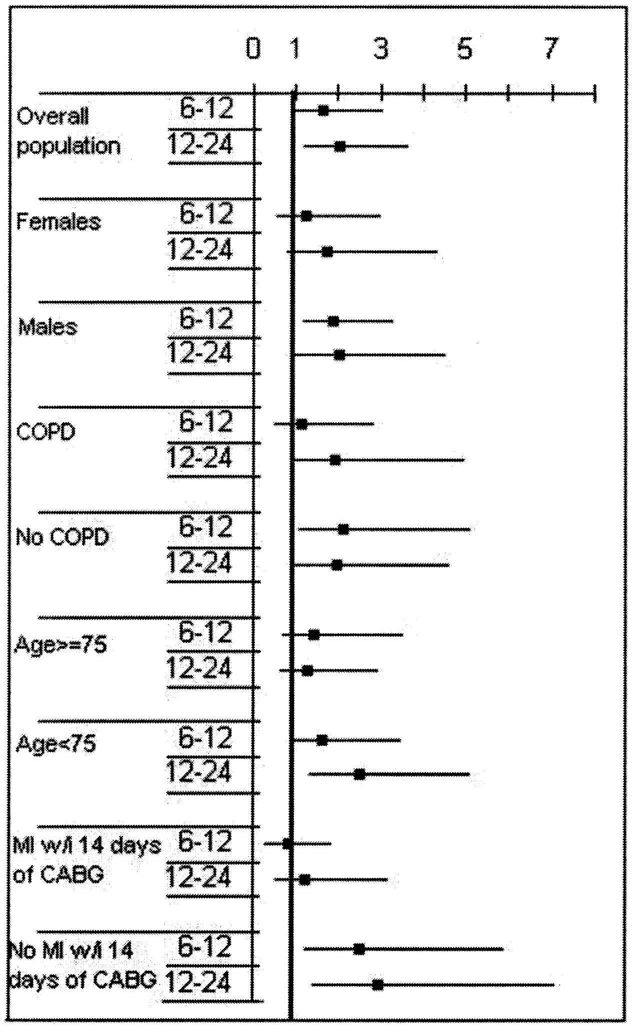

Fig 2. Risk-adjusted odds ratios of mortality in the overall populations and in stratified analyses. Reference category is early extubation subset (0 to 6 hours). Squares *and* horizontal lines *indicate the odds ratio and 95% confidence interval of the odds ratio respectively. Odds ratios greater than 1 indicate an advantage of early extubation. (*CABG = *coronary artery bypass graft surgery;* COPD = *chronic obstructive pulmonary disease;* MI = *myocardial infarction.)*

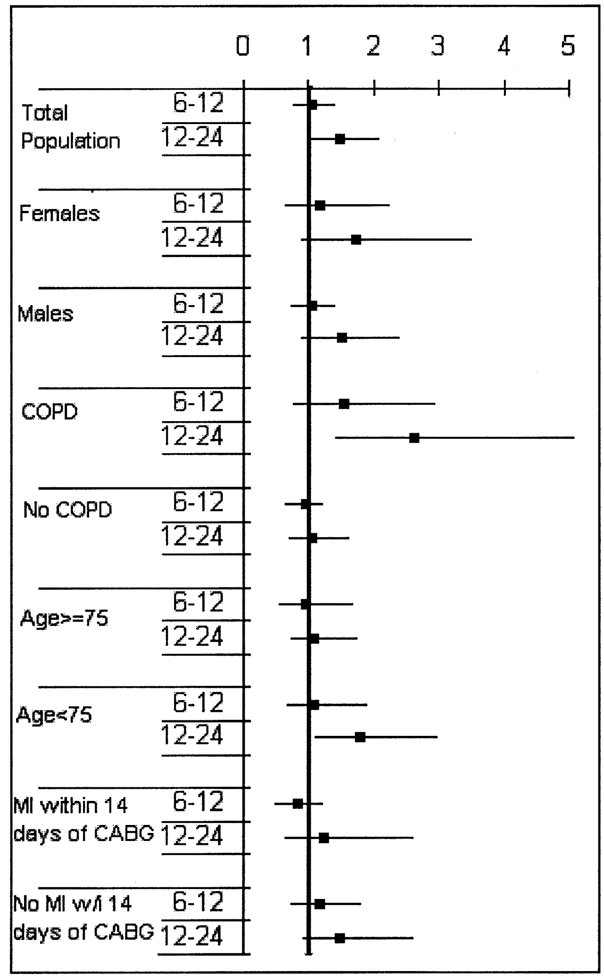

Fig 3. Risk-adjusted odds ratios of reintubation rate in the overall populations and in stratified analyses. Reference category is early extubation subset (0 to 6 hours). Squares *and* horizontal lines *indicate the odds ratio and 95% onfidence interval of the odds ratio respectively. Odds ratios greater than 1 indicate an advantage of early extubation. (*CABG = *coronary artery bypass graft surgery;* COPD = *chronic obstructive pulmonary disease;* MI = *myocardial infarction.)*

matched pairs had very similar baseline clinical characteristics for the early and intermediate extubation group (all p values $>$ 0.341; Table 4). After propensity score matching, pLOS ($p < 0.001$) remained statistically significant in favor of the early extubation group (Table 3). Additionally mortality and reintubation rates were not increased in those extubated early relative to those extubated later.

Comment

While many have proposed the use of early extubation algorithms to reduce resource utilization for CABG patients, some have worried about its safety, particularly among vulnerable populations. In this large community-based study, we found that early extubation was associated with significantly shorter postoperative length of hospital stay and that it can be performed safely, without increasing mortality or reintubation rates. These positive results persisted after careful risk-adjustment among patients with similar propensity for early extubation and among high-risk subgroups.

The question whether early post-CABG extubation leads to shorter postoperative length of stay has rapidly gained importance over the past decade, considering the correlation between length of hospital stay and costs [11, 13]. Although some investigations did not find a difference in postoperative length of stay in early versus late extubated patients [25, 26], most observational studies and small randomized clinical trials showed significant benefits for early extubation [2, 7–9, 11–13, 27]. A recent

Table 3. Independent Predictors for Reintubation in Multiple Logistic Regression Analyses

Parameter	Estimate	Standard Error	p Value	Wald Chi-Square
Hours intubated	0.053	0.011	$<$0.001	23.6
Presence of peripheral arterial disease	0.672	0.134	$<$0.0001	25.2
Myocardial infarction on the day of CABG	1.33	0.339	$<$0.001	15.5
Age	0.046	0.012	$<$0.001	14.0
Current smoker	0.551	0.157	$<$0.001	12.2
Presence of COPD	0.495	0.143	$<$0.001	12.0
Blood urea nitrogen	0.019	0.006	$<$0.001	11.2
Emergency operation	1.041	0.343	0.002	9.2
Other race category	0.947	0.335	0.005	8.0
Ejection fraction per 10% increase	−0.012	0.005	0.016	5.8
Presence of mitral insufficiency	0.428	0.192	0.026	4.9

CABG = coronary artery bypass graft surgery; COPD = chronic obstructive pulmonary disease.

The c-statistic for the logistic regression model (0.723) indicates good discrimination. The Hosmer-Lemeshow goodness-of-fit p value was 0.44, indicating an adequate fitting model.

meta-analysis combining the results of 10 randomized controlled trials provided evidence that postoperative length of stay is shorter in cardiac surgery patients who undergo early extubation [10].

While there is general agreement that early extubation reduces postdischarge hospital stays, debate persists regarding its safety in higher-risk subsets of elderly and comorbid patients [16]. Some investigators are concerned that fast track algorithms that emphasize reduced cardiopulmonary bypass time, improved perioperative monitoring, low use of sedation, and early extubation might increase perioperative adverse events, especially in elderly higher-risk patients [14, 16]. And studies have suggested that continuing anesthetic-level opioids that require mechanical ventilation can reduce perioperative ischemia [28].

To date observational studies and randomized controlled trials have not identified an adverse impact of early extubation on postoperative morbidity [6, 13, 27, 29–32], mortality [6, 9, 13, 29, 30, 32], or reintubation rates [9, 33]. However, these studies were underpowered to adequately assess clinical complications and postoperative mortality [10, 16]. The authors of the meta-analysis [10] stated cautiously that no definite conclusion could be drawn regarding the potential benefit or harm of early extubation on postoperative adverse events. Moreover, many previous studies included a selection of younger low-risk patients and were performed at highly specialized academic centers, clearly limiting the generalizability of the findings [10].

Our analysis adds to the current literature in several ways. First, this was the largest study of early extubation to date, thus allowing us sufficient power to more adequately examine postoperative adverse events. While this analysis concentrated on higher-risk elderly CABG patients, we found no evidence towards increased postoperative risk among those extubated early. In fact, the opposite was seen with early extubation being associated with lower mortality and reintubation rates. Second, the patient population included in the present community-based study reflects the "real-world" situation, increasing the generalizability of our findings.

Our study also revealed that certain subsets such as females, those aged 75 years or older, and those with comorbidities such as COPD or recent MI were significantly less likely to undergo early extubation. This might reflect the fact that anesthesiologists and surgeons are hesitant to initiate early extubation protocols in these patient subsets as perioperative events are feared. However, our investigation demonstrated that when patients in these higher-risk groups were selected for early extubation, there were no observable increase in postoperative event rates (Figs 2, 3). Our study also used propensity matching as an alternative method for adjusting nonrandom treatment comparisons. While some have argued that this method can better control for measured confounders, our findings regarding safety of early extubation after stringent propensity matching were consistent with those seen in our risk-adjusted analyses (Table 3).

Finally, only a few prior studies have evaluated risk factors for reintubation [34, 35]. In our large sample we found that prolonged intubation time, older age, elevated blood urea nitrogen, MI on the day of CABG, history of COPD, presence of peripheral arterial disease, presence of mitral insufficiency, low ejection fraction, current smoking status, "other" race category, and emergency operation were significant predictors for reintubation. Most of these predictors are in line with the findings of previous investigations [34, 35]. Interestingly we found no evidence that early extubation is harmful. On the contrary early extubation was associated with significantly lower risk of reintubation even after risk-adjusting in multivariable analyses. That may be due to higher rates of pulmonary bacterial colonization that can occur with prolonged mechanical intubation [36, 37].

We would like to acknowledge the limitations of our study: Most importantly this study represents a secondary data analysis and is not a prospective randomized clinical trial and therefore patient characteristics strongly differed between the intubation time categories. Although we performed both risk-adjusted multivariable analyses and propensity score matching based on many known confounders it is possible that hidden bias due to unknown confounding was present. In addition our retrospective study could not identify intraand postoperative events that may have altered the decision for early versus later extubation. Despite these limitations the consistency of our findings with those from prior randomized trials generally support the safety and effectiveness of early extubation.

Second, our study did not specifically collect data on the early extubation protocols used among hospitals.

Table 4. Propensity Matched Patient Subgroups

	Overall n = 3,256	0–<6 Hours n = 1,628	6–<12 Hours n = 1,628	*p* Value
Duration of post-CABG intubation in hours, mean (SD)		3.9 (1.4)	8.5 (1.7)	NA
Age in years, mean (SD)		71.8 (5.1)	71.8 (4.9)	0.761
Female sex		31.4%	31.9%	0.764
Race				
Black		4.0%	3.8%	0.786
White		93.6%	93.6%	1.000
Other		2.4%	2.6%	0.736
Coronary artery disease				
History of MI		49.4%	49.9%	0.780
MI on the day of CABG		1.0%	1.2%	0.620
MI within 14 days prior to the CABG		19.8%	20.0%	0.827
Angina within 2 weeks prior to CABG		65.8%	64.5%	0.440
Prior CABG		10.0%	9.8%	0.341
PTCA performed during this admission		1.7%	1.7%	0.892
Left main stenosis ≥ 50%		21.9%	22.1%	0.933
Function				
Ejection fraction, mean (SD)	51.8% (13.5)	52.8% (13.3)	51.8% (13.6)	0.898
Mitral insufficiency	6.4%	6.1%	6.6%	0.518
History of CHF within 2 weeks prior to CABG	12.4%	12.3%	13.5%	0.916
Emergent intubation	0.9%	0.9%	0.9%	1.000
Urgent operation	7.9%	7.7%	8.0%	0.746
History of IMA use in previous surgery	1.9%	2.0%	1.8%	0.699
Comorbidities				
COPD	22.8%	22.9%	22.7%	0.933
Dialyses	0.6%	0.5%	0.6%	0.637
Blood urea nitrogen, mean (SD)	17.5 (7.1)	17.4 (7.4)	17.6 (6.8)	0.741
Diabetes mellitus	27.3%	26.9%	27.6%	0.637
Cerebrovascular accident	9.9%	10.0%	9.8%	0.907
Peripheral vascular disease	39.0%	38.3%	39.7%	0.389
Current smoker	16.6%	16.5%	16.7%	0.888
Postoperative length of hospital stay in days, mean (SD)	7.3 (7.2)	7.0 (3.2)	7.6 (9.7)	<0.001
Discharge within 5 days post-CABG	25.1%	28.6%	21.6%	<0.001
Mortality	1.2%	1.0%	1.4%	0.421
Reintubation	3.0%	2.9%	3.0%	0.836
Intensive care unit readmission	2.9%	2.6%	3.1%	0.344

CABG = coronary artery bypass graft surgery; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; IMA = internal mammary artery; MI = myocardial infarction; NA = not applicable; PCAB = previous coronary artery bypass graft; PTCA = percutaneous transluminal coronary angioplasty.

Thus we cannot compare individual care processes (anesthetic and sedation strategies, and so forth) used to achieve early extubation. Third, our study included few patients that were extubated very early (namely, after less than 3 hours). Thus we cannot comment on whether patients could be safely extubated even earlier as has recently been proposed.

Despite these inherent limitations the present investigation also has numerous strengths. The sample size is larger than in any previous publication, enabling us to assess even rare adverse events with adequate power. Equally important owing to the community hospital based setting of this study the results reflect the effectiveness of early versus intermediate and late post-CABG extubation. This is opposed to many randomized clinical trials for which the highly selected patient samples often limit the generalizability of the study findings.

In summary we have shown that early extubation is associated with significantly shorter postoperative length of stay without increased mortality or frequency of reintubation. Furthermore early extubation was shown to be safe in the overall patient population as well as in the subsets of patients below and above 75 years of age, in male versus female patients, and in patients with and without major comorbidities. Given that early extubation was performed in only 29% of all patients our findings indicate that many centers have not yet fully adapted this concept. These findings suggest that the use of early extubation strategies may be a potential means of reducing hospital costs for CABG in the elderly patient without compromising on their quality or outcomes of care.

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