Outcomes of octogenarians discharged from the hospital after prolonged intensive care unit length of stay after cardiac surgery

Rakesh C. Arora, MD, PhD, FRCSC,^{a,b} Rizwan A. Manji, MD, PhD, MBA, FRCSC,^{a,b}
Rohit K. Singal, MD, MSc, FRCSC,^{a,b} Brett Hiebert, MSc,^b and Alan H. Menkis, DDS, MD, FRCSC^{a,b}

ABSTRACT

Objective: Octogenarians offered complex cardiac surgery frequently experience a prolonged intensive care unit length of stay; however, minimal data exist on the outcomes of these patients. We sought to determine the rates and predictors of 1-year noninstitutionalized survival (“functional survival”) and rehospitalization for octogenarian patients with prolonged intensive care unit length of stay after cardiac surgery and who were discharged from hospital.

Methods: The outcomes of discharged patients aged 80 years or more who underwent cardiac surgery with prolonged intensive care unit length of stay (≥ 5 consecutive days) from January 1, 2000, to December 31, 2011, were examined retrospectively from linked clinical and administrative provincial databases. Regression analysis was used to determine predictors of 1-year functional survival and rehospitalization after discharge from the hospital.

Results: A total of 80 of 683 (11.7%) discharged octogenarian patients had prolonged intensive care unit length of stay. Functional survival at 1 year was 92% and 81% for those with nonprolonged and prolonged intensive care unit lengths of stay, respectively ($P < .01$). Lack of outpatient physician visits within 30 days of discharge (hazard ratio, 5.18; $P < .01$) was a significant predictor of poor 1-year functional survival. The 1-year rehospitalization rates were 38% and 48% for those with nonprolonged and prolonged intensive care unit lengths of stay, respectively, with 41% of all rehospitalizations occurring within 30 days of initial discharge. A rural residence (hazard ratio, 1.82; $P < .01$) and nosocomial pneumonia during patients’ operative admissions (hazard ratio, 2.74; $P < .01$) were associated with rehospitalization within 30 days of discharge.

Conclusions: Octogenarians with prolonged intensive care unit length of stay have acceptable functional survival at 1 year but have high rates of early rehospitalization. Access to health services may influence functional survival and early rehospitalizations. These data suggest that close follow-up of these vulnerable patients after hospital discharge is warranted. (J Thorac Cardiovasc Surg 2017;154:1668-78)

Octogenarians with prolonged ICU LOS have lower functional survival and high rehospitalization rates.

Central Message

Octogenarians with prolonged ICU LOS have lower functional survival and higher rates of rehospitalization versus those without prolonged ICU LOS. Access to health services may influence outcomes.

Perspective

With the increasing number of vulnerable older adult patients being referred for cardiac surgery, there is a need to ensure there is effective in-hospital care (eg, preventing nosocomial pneumonia) and adequate community support (eg, adequate access to outpatient physician services within 30 days) to improve postdischarge outcomes.

See Editorial Commentary page 1679.

Increasing Canadian life span during the past 5 decades has resulted in a higher number of people living past 80 years of age.^{1,2} A growing burden of heart disease in an aging

population has resulted in cardiac surgery being offered to older and increasingly frail patients with multiple comorbidities.^{3,4} After cardiac surgery, although the

From the ^aDepartment of Surgery, and ^bCardiac Sciences Program, University of Manitoba, Winnipeg, Manitoba, Canada.

R.C.A. and R.A.M. have contributed equally as co-first authors for this article.

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Address for reprints: Rakesh C. Arora, MD, PhD, FRCSC, Department of Surgery, Anesthesia & Perioperative Medicine and Physiology & Pathophysiology, University of Manitoba, St Boniface Hospital, CR3012-369 Tache Ave, Winnipeg, Manitoba, Canada R2H 2A6 (E-mail: rakeshcarora@gmail.com).

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Abbreviations and Acronyms

ICU = intensive care unit

LOS = length of stay

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majority of patients require recovery in a postoperative intensive care unit (ICU) environment for less than 48 hours, many patients experience a more complicated course, resulting in a prolonged ICU length of stay (LOS).²⁻⁸ Patients who have a prolonged ICU LOS after cardiac surgery experience higher rates of rehospitalization with associated worse functional capacity,⁵ worse health-related quality of life,^{6,7} increased healthcare costs, and lower rates of noninstitutionalized survival (ie, being alive and in their own home).⁸

A recent examination of the outcomes of approximately 9500 cardiac surgery cases performed in Manitoba over a 10-year period has demonstrated that the number of patients

who experienced a prolonged ICU LOS after cardiac surgery (defined as requiring an ICU admission for ≥ 5 days) has increased from 7% between 2000 and 2009 to greater than 11% between 2010 and 2013 (a relative increase of 57%).⁸ Furthermore, a significant increase in the numbers of patients aged 80 years or older has been observed at the University of Manitoba (Figure 1). At present, people aged 80 years or more represent the Canadian demographic with the fastest growth rate, more than tripling in number over the last 3 decades.² Therefore, the number of older adult patients undergoing heart surgery and experiencing prolonged ICU LOS will only continue to increase.

Although recent investigations have sought to understand outcomes in octogenarian patients undergoing cardiac surgery,⁹⁻¹² the long-term functional impact for those patients who require prolonged ICU LOS after cardiac surgery remains unclear. This leads to challenges in decision making on the indication and timing of surgery, in conversations with the patient and their caregivers in times of unanticipated outcomes, and in ensuring adequate discharge planning for these vulnerable patients. Therefore, we sought to examine the long-term impact of prolonged ICU LOS on the octogenarian patient to determine predictors for adverse outcomes, such as poor functional survival (ie, dead or institutionalized)⁸ and rehospitalization. We hypothesized that octogenarians with a prolonged ICU LOS have a lower rate of functional survival and higher rates of rehospitalization 1 year after their cardiac surgery procedure.

FIGURE 1. Proportion of the Manitoban general and cardiac surgical population aged 80 years or more. The rate of provincial rate of octogenarians (orange line) has been stable, whereas the number of patients undergoing cardiac surgery (blue line) has approximately doubled over a 10-year period.

METHODS AND MATERIALS

This was a single-region, single-center retrospective database study. Approval was obtained from the institutional research ethics boards and the Manitoba Health Information Privacy Committee. Informed consent was waived for this retrospective, deidentified database study.

Databases

The Manitoba Centre for Health Policy at the University of Manitoba's Rady Faculty of Health Sciences in Winnipeg, Manitoba, Canada, houses several provincial clinical and administrative databases within the Population Health Research Data Repository. The clinical data for this study were derived from the Winnipeg Regional Health Authority ICU database and the Manitoba Cardiac Surgical Database as previously described.⁸ Separation abstracts data provided information about an individual's initial cardiac surgery hospitalization and any subsequent rehospitalization. Medical Claims (physician billings) data determined the degree of outpatient interaction a patient had with his/her physician after discharge. Long-term care and vital statistics data provided an individual's functional status (alive and noninstitutionalized). Only new institutional (ie, nursing home or other long-term care facility) admission is included within this definition. If a patient was transferred to another facility before being discharged to home, time to the first rehospitalization or institutionalization was determined from that facility. Social Assistance data provided information on individuals requiring any income assistance before or after cardiac surgery. Costs for the initial cardiac surgery hospitalization and subsequent rehospitalizations occurring within 1 year after hospital discharge were determined by a validated method established by the Manitoba Centre for Health Policy.¹³ This method used the Canadian Institute for Health Information resource intensity weights to measure the intensity of resource use associated with a particular inpatient hospitalization relative to a standard hospitalization. Multiplying the resource intensity weight value by the cost per weighted case (obtained from the 2013/2014 fiscal year) allows one to obtain an approximation of costs associated with each hospitalization in 2013/2014 Canadian dollars.

Publicly available data from Statistics Canada provided neighborhood-level income data across the entire province of Manitoba. Each neighborhood was assigned to a provincial income quintile. The databases have been validated and used in a previous study.⁸

Patient Population

The study population included all patients aged 80 years or more who underwent cardiac surgery between January 1, 2000, and December 31, 2011, from a single healthcare region with a catchment area of approximately 1 million people who were eventually discharged from the hospital. Patients requiring extracorporeal membrane oxygenation for postcardiotomy indications were included. The prolonged ICU LOS cohort was defined as patients requiring 5 or more consecutive days in the ICU after their index cardiac surgery based on an optimal cutpoint determination from our dataset.¹⁴ Those with prolonged ICU LOS were compared with those without prolonged ICU LOS. Only patients who reside in Manitoba are included in this analysis. Patients who reside outside of Manitoba were not included because it is not possible to link their data with the Provincial data repository.

The primary outcome of interest was "functional survival," defined as alive and not requiring a long-term institutional admission (ie, living in their own home) within 1 year after discharge from their operative hospital admission.⁸ The secondary outcome of interest was early (30-day) and 1-year rehospitalization after discharge to home.

Data Analysis

Continuous variables were compared using a *t* test (for parametric data) or Mann-Whitney test (for nonparametric data), and categorical variables were compared using a chi-square or Fisher exact test where appropriate.

Rates of functional survival were calculated using Kaplan-Meier survival curves and compared between those with nonprolonged ICU LOS and those with prolonged ICU LOS using a log-rank test. Rates of first hospital readmission were calculated using cumulative incidence curves with a competing risk of death before rehospitalization for up to 1 year postdischarge, and the values were compared between nonprolonged ICU LOS and prolonged ICU LOS cases using Gray's test.

In addition, a multivariable Cox proportional hazard model was developed to further characterize the factors associated with time to functional survival up to 1 year and first readmission to hospital within 30 days of hospital discharge for the entire study cohort of patients aged 80 years or more. All variables presented in Table 1 taken from both clinical and administrative data sources were considered for the final model. Multiple imputation with a Markov Chain Monte Carlo equation was applied to handle all missing covariate values. A stepwise selection method was used that considered the score test criteria with a *P* value less than .05 for entry of variables into the model and the Wald test criteria with a *P* value greater than .05 for removal of selected variables. Statistical analysis was undertaken using SAS software, version 9.3 of the SAS System for Windows (SAS Institute Inc, Cary, NC).

RESULTS

Patient Demographics

A total of 743 patients aged 80 years or more underwent a cardiac surgery procedure during the study period (Figure E1). Octogenarians with prolonged ICU LOS experienced a higher in-hospital mortality (primarily in the ICU) rate ($25/105 = 23.8\%$) versus the nonprolonged ICU LOS cohort ($35/638 = 5.5\%$; $P < .01$).

Of 683 patients who underwent cardiac surgery who survived to hospital discharge, 80 (11.7%) experienced a prolonged ICU LOS after their procedure. Octogenarian patients who required prolonged ICU LOS were more commonly female and typically presented with a higher level of acuity, frequently with cardiogenic shock (Table 1).

Operative Characteristics and Intensive Care Unit Complications

Octogenarian patients with prolonged ICU LOS tended to have undergone a complex procedure (ie, procedure other than isolated coronary artery bypass grafting or valve procedure) and more frequently with higher urgency status and cardiogenic shock (Table 2). The ICU LOS was 5 times longer and total hospital LOS was twice as long in octogenarians with prolonged ICU LOS versus those with nonprolonged ICU LOS (Table 2).

Survival and Functional Survival

The 1- and 5-year unadjusted survivals of patients aged 80 years or more who underwent cardiac surgery and had prolonged ICU LOS and nonprolonged ICU LOS are shown in Figure 2 with further comparison with the survival curve for an age- and sex-matched provincial population via publicly available data from Statistics Canada. Patients aged 80 years or more who did not have prolonged ICU LOS had higher survival after cardiac surgery compared with the age- and sex-matched general population. Figure 3

TABLE 1. Patient characteristics for octogenarian patients who underwent cardiac surgery and survived to hospital discharge

Variable	Nonprolonged ICU LOS cohort (n = 603)	Prolonged ICU LOS cohort (N = 80)	P value
Preoperative variables			
Age, y	82 (81-84)	82 (81-83)	.72
Female	225 (37.3%)	41 (51.3%)	.02
BMI (kg/m ²)	26.9 (24.5-29.8)	26.9 (24.9-31.2)	.49
Previous MI	294 (48.8%)	39 (48.8%)	1.00
Diabetes mellitus	127 (21.1%)	15 (18.8%)	.63
Peripheral vascular disease	135 (22.4%)	16 (20.0%)	.63
History of arrhythmia	109 (18.1%)	20 (25.0%)	.14
Congestive heart failure	105 (17.4%)	21 (26.3%)	.06
COPD	60 (10.0%)	9 (11.3%)	.72
Renal insufficiency (creatinine >1.8 mg/dL)	66 (11.0%)	13 (16.3%)	.16
Cerebrovascular disease	85 (14.1%)	13 (16.3%)	.61
Previous mental health condition	93 (15.4%)	13 (16.3%)	.85
Cardiogenic shock	8 (1.3%)	14 (17.5%)	<.01
Ejection fraction			.12
≥50%	388 (64.3%)	43 (53.8%)	
35%-49%	154 (25.5%)	24 (0.0%)	
<35%	61 (10.1%)	13 (16.3%)	
Nonelective surgery	31 (5.1%)	18 (22.5%)	<.01

Categorical variables compared using chi-square test. Continuous variables are compared using Mann-Whitney test. Categorical variables are expressed as N (%). Continuous variables are expressed as median (quartile 1-quartile 3). *ICU*, Intensive care unit; *LOS*, length of stay; *BMI*, body mass index; *MI*, myocardial infarction; *COPD*, chronic obstructive pulmonary disease.

demonstrates the functional survival (alive and noninstitutionalized) of the studied patient population. Octogenarian patients with prolonged ICU LOS had a lower rate of the primary outcome of functional survival 1 year after discharge from the hospital (81.3% prolonged ICU LOS vs 91.7% nonprolonged ICU LOS; $P < .01$). This poor functional survival trend continued up to 5 years (57.6% vs 70.1%; $P < .01$) from hospital discharge. A Cox proportional hazards model was generated on the total octogenarian cohort, which identified 4 factors associated with poor 1-year functional survival (Table 3). Lack of outpatient physician visits within 30 days of discharge was associated with a 5-fold increased risk of poor 1-year functional survival (hazard ratio, 5.18; $P < .01$).

Hospital Readmission

The times to first rehospitalization rates in octogenarian patients who had survived to hospital discharge after cardiac surgery are shown in Figure 4. The need for rehospitalization was high in all patients aged 80 years or more, with 41% of rehospitalizations occurring within the first 30 days postdischarge; however, this was not statistically different between those with prolonged ICU LOS and those with nonprolonged ICU LOS. For patients rehospitalized within 1 year of discharge, the median interquartile range time to first rehospitalization was 54 (11-179) days in the nonprolonged ICU LOS cohort versus 41 (12-160) days in the prolonged ICU LOS cohort ($P = .63$). The total cumulative hospital bed days occupied within the first year of discharge

were 5327 days for those with nonprolonged ICU LOS (8.8 days/patient) and 1109 days for those with prolonged ICU LOS (13.9 days/patient) ($P = .12$). The most common broad category reasons for rehospitalization were heart failure, diabetes, and ischemic heart disease. Regression analysis demonstrated living in a rural setting (hazard ratio, 1.82; 95% confidence interval, 1.25-2.66; $P < .01$) and nosocomial pneumonia during the index cardiac surgery hospitalization (hazard ratio, 2.74; 95% confidence interval, 1.28-5.90; $P < .01$) as associated with the time to first rehospitalization within 30 days of discharge in patients aged 80 years undergoing cardiac surgery.

Costs

The total median (interquartile range) cost within the first year of cardiac surgery for patients aged 80 years or more who were discharged from the hospital was \$33,945 (C\$24,798-C\$50,874) for those with nonprolonged ICU LOS versus \$75,798 (C\$53,471-C\$127,624) for those with prolonged ICU LOS ($P < .01$). These costs were largely due to initial hospitalization costs (vs rehospitalization costs). The index cardiac surgery hospital costs were \$29,483 (\$22,036-\$39,419) for those with nonprolonged ICU LOS and \$65,658 (\$46,010-\$103,612) ($P < .01$) for those with prolonged ICU LOS.

DISCUSSION

In this analysis, we sought to understand the impact of functional survival⁸ and early rehospitalization in a

TABLE 2. Operative, intensive care unit, and postdischarge patient characteristics for octogenarian patients undergoing cardiac surgery

Variable	Nonprolonged ICU LOS cohort (n = 603)	Prolonged ICU LOS cohort (N = 80)	P value
Operative variables			
Procedure type			<.01
Isolated CABG	362 (60.0%)	32 (40.0%)	
Single non-CABG	106 (17.6%)	13 (16.3%)	
≥2 procedures	135 (22.4%)	35 (43.8%)	
Crossclamp time (min)	65 (48-98)	86 (52-126)	<.01
Cardiopulmonary bypass time (min)	103 (77-141)	127 (88-184)	<.01
Postoperative variables			
APACHE II score	16 (14-18)	19 (16-22)	<.01
APACHE II ≥20	92 (15.3%)	37 (46.3%)	<.01
Mechanical ventilation (d)	1 (0-2)	5 (2-7)	<.01
Reintubation	9 (1.5%)	17 (21.3%)	<.01
Blood products			
Red blood cells (units)	1 (0-2)	3 (2-6)	<.01
Fresh-frozen plasma (units)	0 (0-0)	2 (0-6)	<.01
Platelets (units)	0 (0-0)	0 (0-5)	<.01
ICU complications			
Tachyarrhythmias	71 (11.8%)	46 (57.5%)	<.01
Other cardiovascular procedure (sternal rewiring, returns to operating room, other)	42 (7.0%)	28 (35.0%)	<.01
Thrombocytopenia	44 (7.3%)	18 (22.5%)	<.01
Cardiogenic shock	30 (5.0%)	26 (32.5%)	<.01
Delirium	22 (3.7%)	12 (15.0%)	<.01
Congestive heart failure	15 (2.5%)	7 (8.8%)	<.01
Other pulmonary/thoracic procedures	7 (1.2%)	12 (15.0%)	<.01
Acute renal insufficiency (creatinine >1.8 mg/dL)	18 (3.0%)	16 (20.0%)	<.01
LOS			
ICU LOS (d)	1.2 (0.9-2.6)	6.8 (5.8-9.9)	<.01
Hospital LOS (d)	13 (8-21)	30 (22-51)	<.01
Postoperative follow-up with any physician			.05
No physician visits within 30 d of discharge	56 (9.3%)	14 (17.5%)	
1-4 visits within 30 d of discharge	478 (79.3%)	55 (68.8%)	
5+ visits within 30 d of discharge	69 (11.4%)	11 (13.8%)	

Categoric variables compared using chi-square test. Continuous variables compared using Mann-Whitney test. Categoric variables expressed as N (%). Continuous variables expressed as median (quartile 1-quartile 3). ICU, Intensive care unit; LOS, length of stay; CABG, coronary artery bypass grafting; APACHE, Acute Physiology And Chronic Health Evaluation.

particularly vulnerable group of patients with prolonged ICU LOS, namely, those aged 80 years or more. This study identified that, in general, octogenarian patients with a prolonged ICU LOS tended to have undergone a complex procedure, frequently on an urgent or emergency basis and often in cardiogenic shock. This affected both short-term (1-year) and long-term (5-year) functional survival, although functional survival was still reasonable at more than 80% for 1 year and more than 50% at 5 years (Figure 3). In addition, all patients aged 80 years or more experienced high rates of early rehospitalization, although most of the costs for the first year after the surgical procedure were encountered during the index cardiac surgery hospitalization. Although there have been several important reports examining short- and long-term outcomes in patients aged 80 years or more, the strength of this analysis

was the inclusion of a large cohort of patients with mixed procedure type and longitudinal outcome (up to 5 years), as well as cost data. With an increasing number of octogenarians presenting for cardiac surgery, understanding the outcomes of these patients and factors that can change the outcomes is increasingly important for patients, families, healthcare providers, and administrators.

With recent important reports examining outcomes in the now aging population undergoing cardiac surgery, hospital discharge is frequently cited as the metric to a “successful” procedural outcome.¹¹ However, as demonstrated in this and previous analyses,^{12,15,16} survival after a complicated ICU and hospital stay does not necessarily translate to “thriving” in the community after hospital discharge. In the current era of cardiac surgery, there is a need to further understand patient-centered outcomes. Indeed,

FIGURE 2. Kaplan–Meier survival curve: 5-year survival by ICU LOS in patients aged 80 years or more compared with the age- and sex-matched Manitoba population survival curve (95% confidence intervals indicated by the dashed line). Note that patients with nonprolonged ICU LOS after cardiac surgery have better survival compared with an age- and sex-matched provincial population. *P* value of .06 (log rank) comparing nonprolonged ICU LOS and prolonged ICU LOS. *prICULOS*, Prolonged intensive care unit length of stay; *CI*, confidence interval.

functional capacity is increasingly recognized as an important patient-centric value, perhaps more so than hospital survival, to older adult patients undergoing cardiac surgery.^{5-7,17} Bashour and colleagues⁵ have promoted this in their recommendation that understanding outcomes of the patient with prolonged ICU LOS is most appropriately examined in the long-term follow-up of these patients after discharge from their index hospital admission.

The clinical significance of this and other important work examining outcomes in the older adult undergoing cardiac surgery is important to understand current and predict future rates of healthcare resource use. Second, it is anticipated that knowledge of short- and long-term functional outcomes can facilitate the informed consent and shared decision-making processes with the patient and their caregivers. It is increasingly clear that even complex operations can be performed in patients aged more than 80 years,^{12,18} and this is supported by the data in this analysis wherein the 5-year survival curve of those with nonprolonged ICU LOS cardiac surgery appears higher than in the age-matched general (noncardiac surgery) population, an important verification of the suitability of this treatment for octogenarians. Conversely, octogenarian patients who require a prolonged ICU stay experience lower rates of functional survival after their cardiac surgery procedure. Furthermore, the “successfully” discharged octogenarian patient still appears to

experience higher rates of rehospitalization. The lack of access to timely physician visits was associated with a significantly lower rate of functional survival. This is in keeping with recent frailty theories that propose that “damage begets damage,” which may, in part, account for the persistent decrease in functional survival 5 years from the initial cardiac surgical procedure.¹⁹ Therefore, further work to identify processes of care that require optimization predischarge and postdischarge to improve the patient journey and ensure that patients continue to successfully recover in the community after hospital discharge is needed.

It seems that a “multi-armed” approach to improve outcomes for octogenarians undergoing cardiac surgery may be considered on the basis of the data generated from this study. The first relates to preoperative referral. A notable finding from this analysis was the higher proportion of female patients and patients with high urgency in the prolonged ICU LOS group. It is unclear whether this represents a referral bias in which older (and perhaps female) patients are not being referred early in their disease process, are refusing to undergo a surgical procedure at the initial consultation, or are presenting with more advanced disease. Although it is not possible to completely understand this phenomenon, it is worthy to consider that patients, their families, and physicians may be pursuing surgical therapies only as a last resort, leading to late referral. Given the results

FIGURE 3. Kaplan-Meier survival curve: 5-year functional survival (alive and not institutionalized) by ICU LOS in patients aged 80 years or more who were discharged from the hospital alive. Functional survival was significantly lower in patients who experienced a prolonged ICU LOS (prolonged ICU LOS, red line) versus those who did not (nonprolonged ICU LOS, green line) after their cardiac surgery procedure at 1 and 5 years (95% confidence intervals indicated by the dashed line). prICULOS, Prolonged intensive care unit length of stay; CI, confidence interval.

of the lower-acuity patients in our study, it is reasonable to diminish apprehension around cardiac surgery for octogenarians and promote early surgical consultation.

The second prong relates to the management of patients experiencing prolonged ICU LOS postoperatively and on transition to the community. In this analysis, important and potentially actionable factors of negative 1-year outcomes for the specific group of patients who have experienced prolonged ICU LOS were identified. For example, quality-improvement initiatives that seek to prevent nosocomial infection may have benefits in this vulnerable population to avoid rehospitalizations.²⁰ However, the transition from a tertiary care institution to a community is likely not as readily addressed. Octogenarian patients with prolonged ICU LOS may have to deal with multisystem healthcare issues that are overwhelming for themselves, their caregivers, and their primary care practitioner.^{21,22} At present, there seems to be a lack of a comprehensive approach for these patients, particularly for the rural patient.²³ With newer minimally invasive procedures now being performed in frail octogenarian and nonagenarian patients previously deemed inoperable, it has become critically important for the healthcare systems to develop strategies to improve clinical outcomes and provide patient and caregiver support.²⁴⁻²⁸ As such, it may be appropriate to consider new models of care using a team-based healthcare delivery model to provide comprehensive medical care to patients with the goal

of obtaining maximized health outcomes after hospital discharge.²⁹

Study Limitations

We were limited by the nature of a retrospective design and reporting data from a single tertiary care center. Furthermore, despite examining outcomes over a 10-year period, a sample size of 80 patients limits the ability of additional subgroup analysis or examination of different LOS cutpoints. In addition, we were limited to the use of aggregate data that prevented more granular insight into the causes of in-hospital mortality in the octogenarian with prolonged ICU LOS. However, we were able to link our surgical database with a detailed provincial administrative data repository to obtain approximately 100% complete data on patient outcomes in our dataset. Second, although we were able to report on the “traditional” patient factors that inform perioperative risk, we did not capture information that categorizes levels of frailty that have been shown to influence postoperative outcomes.³⁰⁻³³ Previous investigations have examined the role of preoperative exercise interventions in patients undergoing cardiac surgery (“prehabilitation”),^{34,35} with a current study under way examining its utility in the frail older adult.³⁶ Third, the process of discharge from the ICU to the ward and the ward to home, although undergoing significant evolution over time, still relies on some degree of subjective medical decision making. This creates a

FIGURE 4. Cumulative incidence curve: 1-year first rehospitalization rates by ICU LOS for patients aged 80 years or more undergoing cardiac surgery. The 1-year rehospitalization cumulative incidence curve for patients aged 80 years or more with (red line) or without (green line) a prolonged ICU LOS (prolonged ICU LOS) after the cardiac surgery procedure demonstrates that rehospitalization rates are high for octogenarians but statistically similar based on ICU LOS (95% confidence intervals indicated by the dashed line). *prICULOS*, Prolonged intensive care unit length of stay; *CI*, confidence interval.

possibility that patient discharge is not taking place appropriately on an institutional basis that would have a significant impact on LOS and potential for readmission. There are many facets of our clinical program that attempt to mitigate this possibility. As of 2007, we have a 24-hour in-house intensivist physician staffing model.^{37,38} Decisions to discharge a patient are made on daily bedside rounds with the interdisciplinary team consisting of the medical doctor, physiotherapist, nursing, pharmacy, respiratory therapist, and dietician. Patients who are not ready for transfer typically are reevaluated by 3 PM to determine whether transfer to the ward is appropriate at that stage. For the ward to discharge home (or elsewhere), our team holds 2 interdisciplinary disciplinary meetings per week that involve clinical assistants/physician assistants, nurses, physiotherapy and occupational therapy, social work, and home care service. In general, patients are sent home when all team members are in agreement that they are capable with appropriate support in place. This includes specific physiotherapy criteria, including safe transfers, walking, and climbing stairs. Given the thorough and multidisciplinary nature of this process, we believe that hospital discharges take place appropriately at our institution and potentially even on a somewhat conservative basis lower the likelihood of premature discharge. Fourth, the process of care for the octogenarian after hospital discharge was not fully clear. Although we

are able to determine whether a patient was living in his/her own home (vs a personal care home or another type of long-term care facility), we are unable to determine what level of in-home services may have been required by the patient and caregivers. Last, we did not have detailed information on health-related quality of life, patient and caregiver stress burden, and lost revenue, which certainly have an impact on patient-specific outcomes. Our team is currently examining several of these limitations in a prospective fashion.

CONCLUSIONS

This retrospective analysis of 683 patients aged 80 years or more who underwent cardiac surgery and survived to

TABLE 3. Multivariable Cox proportional hazards regression variables associated with time to death or institutionalization up to 1 year postdischarge for octogenarians

Variable	HR	95% CI	P value
Diabetes mellitus	2.86	1.68-4.85	<.01
APACHE II ≥ 20	1.90	1.08-3.34	.03
Hospital LOS (per day)	1.02	1.01-1.02	<.01
No physician visits vs 1-4 physician visits within 30 d of discharge	5.18	2.93-9.16	<.01

HR, Hazard ratio; CI, confidence interval; APACHE, Acute Physiology And Chronic Health Evaluation; LOS, length of stay.

hospital discharge found that those who experienced prolonged ICU LOS have significantly lower, but acceptable functional survival at 1 and 5 years compared with those without prolonged ICU LOS. Furthermore, those with prolonged ICU LOS had a higher proportion of women, high acuity, and cardiogenic shock, suggesting possible referral biases that may need to be addressed, especially considering that patients with nonprolonged ICU LOS had better survival than the age- and sex-matched general population. In addition, all patients aged 80 years or more experienced high rates of rehospitalization after cardiac surgery. The development of healthcare processes that assist the transition of the octogenarian patient who underwent cardiac surgery from a tertiary care center to the community is warranted.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: http://webcast.aats.org/2016/Video/Monday/05-16-16_Room_337_1600_Arora-800.mp4.

Conflict of Interest Statement

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Key Words: cardiac surgery, critical care, functional survival, octogenarian, rehospitalization

Discussion

Dr K. Bando (Tokyo, Japan). This study is a natural extension of your previous study involving a cohort of 9545 adult patients that used a similar study design and was presented at the 2015 Society of Thoracic Surgeons meeting. You mentioned a 2-pronged approach to the improved outcomes for octogenarian patients

in your article, preoperative referral, and management of the ICU period and transition to the community. However, I believe modifiable factors that can reduce the length of ICU stay and provide adequate postdischarge care are the most important considerations when looking to

provide good late functional outcomes for these vulnerable patients.

My first question is related to preoperative patient characteristics. You mentioned that female gender and urgent and emergency procedures were more frequently seen in the prolonged ICU stay group. What about the Society of Thoracic Surgeons (STS) score or nutritional status defined by body mass index or other serum albumin level? Do you have any data indicating whether those factors may have any impact on the length of ICU stay or late functional survival?

Dr R. C. Arora (Winnipeg, Manitoba, Canada). Although we collected Euro-opean System for Cardiac Operative Risk Evaluation II for a portion of the study period, we didn't collect STS or STS Predicted Risk of Mortality on our patients, because this was not available for the entire duration of our patient cohort. With linkages to our ICU database, we are able to look at Acute Physiology And Chronic Health Evaluation II scores, which are shown for you in our Table 2. There are differences with the baseline Acute Physiology And Chronic Health Evaluation II scores.

Although Acute Physiology And Chronic Health Evaluation II is not specifically validated in a cardiac surgery patient population, it does provide some severity of illness information that may be more relevant to the ICU patient than specifically a preoperative cardiac surgery patient risk score.

Second, although a number of patient factors were considered, we acknowledge the limitation of not having detailed information on certain important contemporary issues (eg, frailty) or nutrition scores (eg, body mass index or albumin).

We are looking at ways to link this to laboratory data within our province, and we may have that ability in the future. The last several months, we've been collecting frailty data in a prospective fashion on elective patients going to the center, and we also hope to be able to present these data sometime in the future.

Dr Bando. As you know, the length of ICU stay was not determined only by preoperative factors. Did intraoperative factors, including pump time, crossclamp time, transfusion requirement, and surgeon's performance, have any impact on length of ICU stay and subsequent functional survival or readmission rate for those patients who are 80 years or older?

Dr Arora. A number of intraoperative factors (eg, transfusion pump time, crossclamp time) are considered, as shown for you in Table 2. However, they were considered as potential covariances in our model but were not significant. We don't specifically have a surgical performance

measure or metric, but I'd be interested in learning more if you do something along those lines. But we don't specifically have a tool for that.

Dr Bando. When, how, and by whom is the decision to discharge those patients to their homes or other facilities made? Is it a team decision-making process consisting of members from different disciplines? Are there any standardized protocols for discharge? Is there any possibility of patients being discharged prematurely?

Dr Arora. I'll divide that into 2 groups: the ICU discharge and ward discharge, which likely play a role in both those factors. So as of 2007, we've had a different staffing model in which we have in-house consultant intensivists and cardiac anesthesiologist on a 24-hour basis that assess the patient as part of the morning interdisciplinary rounds. These rounds include the charge and bedside nurse, the respiratory therapist, physiotherapist, pharmacists, and so forth. We then will often reassess an individual patient several times during the course of the day to know if she or he meets (somewhat admittedly subjective) criterion for ICU discharge. Our actual return to ICU rates are relatively low. They're actually too small for us to examine because of the number of patients for this analysis.

For the ward to discharge home or to another institution, we've developed an interdisciplinary meeting that occurs twice a week to discuss discharge planning. That has been a process that has evolved in the last 3 to 4 years in which we involve the physician assistants, nurses, allied health team members, and home care to plan what services that may be required.

In general, I would suggest that we have a relatively conservative approach to discharge, because particularly in Manitoba, we serve a large geographic distance. To ensure that patients have the appropriate transportation and knowledge of who is receiving community-based practice are important considerations that may delay discharge. With regard to where patients are discharged, approximately 15% go to some other institution after our hospital, and it was more common in the patient with prolonged ICU LOS than those who had a typical course after surgery.

Dr G. Hirsch (*Halifax, Nova Scotia, Canada*). Congratulations on a well-done study and an important question as we all face increasing octogenarians with a lot of comorbidities and increasingly complex procedures. We've shown the same trends in Halifax, and as you know, we've been interested in

frailty and decision making as you alluded to in this group. It's important to get at their ultimate fate as you're starting to get a handle on a difficult question to nail down because that's what an 80-year-old patient wants to know is am I going to get back to any functional capacity.

We both live in sort of centralized worlds of a single center serving an entire province. What mitigating strategies are you going to put in place for access to a physician who varies extremely between rural and almost no access back to the primary institution once they're discharged far away?

Dr Arora. Right. So this was part of the motivation for this question to start with in addition to changing in practice and now offering procedures to patients deemed previously inoperable with transcatheter aortic valve implantation programs and so forth that started after we did this analysis.

We looked at what cost the most as a way of trying to start to answer this problem, and a lot of that comes to their index hospital admission. When patients are discharged, although there is a high rate of return to hospital, the actual incremental cost of those are less. Therefore, it is reasonable to invest more effort or money spent up front and coordinate a short duration hospital stay and plan appropriately for hospital discharge.

We are currently in the process of developing prospectively a bidirectional communication tool with our community-based primary care practitioners to allow closing a loop with the information for discharge planning. Then when problems arise, we hope to have a clear process for reengaging the cardiac surgery center to answer questions or problems remotely or actually when to bring them back to the hospital so people don't slip through the cracks as time goes on.

FIGURE E1. Patient cohort diagram. *ICU*, Intensive care unit; *prICU-LOS*, prolonged intensive care unit length of stay.

TABLE E1. Univariable Cox proportional hazards regression: Variables associated with functional survival time up to 1 year after discharge for octogenarians

Variable	HR	95% CI	P value
Preoperative variables			
Age	1.03	0.93-1.15	.54
Female	0.80	0.48-1.33	.39
BMI (kg/m ²)	1.01	0.95-1.07	.76
Previous MI	0.83	0.51-1.36	.47
Diabetes mellitus	2.17	1.31-3.61	<.01
Peripheral vascular disease	1.38	0.80-2.37	.25
History of arrhythmia	0.86	0.45-1.65	.66
Congestive heart failure	0.90	0.47-1.73	.76
COPD	1.25	0.60-2.63	.55
Renal insufficiency (Cr >1.8 mg/dL)	1.42	0.72-2.79	.31
Cerebrovascular disease	1.24	0.65-2.36	.52
Previous mental health condition	1.12	0.58-2.13	.74
Cardiogenic shock	1.47	0.46-4.67	.52
Ejection fraction			
35%-49% vs ≥50%	1.54	0.91-2.59	.11
<35% vs ≥50%	0.78	0.31-1.99	.60
Nonelective surgery	2.85	1.49-5.46	<.01
Year of surgery	0.96	0.90-1.03	.31
Operative variables			
Procedure type			
Single non-CABG vs isolated CABG	1.32	0.70-2.51	.39
≥2 procedures vs isolated CABG	1.36	0.77-2.39	.29
Crossclamp time (min)	1.00	1.00-1.01	.48
Cardiopulmonary bypass time (min)	1.00	1.00-1.01	.16
Postoperative variables			
APACHE II ≥20	2.32	1.39-3.87	<.01
Mechanical ventilation (d)	1.20	1.09-1.32	<.01
Reintubation	3.34	1.53-7.32	<.01
Blood products			
Red blood cells (Units)	1.12	1.06-1.18	<.01
Fresh-frozen plasma (Units)	1.06	0.99-1.13	.09
Platelets (Units)	1.08	1.04-1.13	<.01
ICU complications			
Other CV procedure (sternal rewiring, returns to OR, other)	1.44	0.71-2.91	.31
Thrombocytopenia	1.45	0.69-3.04	.32
Cardiogenic shock	2.14	1.09-4.20	.03
Acute renal insufficiency (Cr >1.8 mg/dL)	2.98	1.42-6.24	<.01
LOS			
ICU LOS (d)	1.11	1.07-1.16	<.01
Prolonged ICU LOS (≥5 d)	2.35	1.32-4.19	<.01
Hospital LOS (d)	1.02	1.02-1.03	<.01
Postoperative follow-up with any physician			
No physician visits within 30 d of discharge vs 1-4 visits	4.98	2.90-8.56	<.01
5+ visits within 30 d of discharge vs 1-4 visits	1.23	0.55-2.75	.62

HR, Hazard ratio; CI, confidence interval; BMI, body mass index; MI, myocardial infarction; COPD, chronic obstructive pulmonary disease; Cr, creatinine; CABG, coronary artery bypass grafting; APACHE, Acute Physiology And Chronic Health Evaluation; ICU, intensive care unit; CV, cardiovascular; OR, operating room; LOS, length of stay.