



# PATIENTS' CHARACTERISTICS ASSOCIATED WITH READMISSION TO A SURGICAL INTENSIVE CARE UNIT

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**Background** Readmission within 48 hours is a leading performance indicator of the quality of care in an intensive care unit.

**Objective** To investigate variables that might be associated with readmission to a surgical intensive care unit.

**Methods** Demographic characteristics, severity-of-illness scores, and survival rates were collected for all patients admitted to a surgical intensive care unit between 1995 and 2000. Long-term survival and quality of life were determined for patients who were readmitted within 30 days after discharge from the unit. Quality of life was measured with the EuroQol-6D questionnaire. Multivariate logistic analysis was used to calculate the independent association of expected covariates.

**Results** Mean follow-up time was 8 years. Of the 1682 patients alive at discharge, 141 (8%) were readmitted. The main causes of readmission were respiratory decompensation (48%) and cardiac conditions (16%). Compared with the total sample, patients readmitted were older, mostly had vascular (39%) or gastrointestinal (26%) disease, and had significantly higher initial severity of illness ( $P=.003$ ,  $.007$ ) and significantly more comorbid conditions ( $P=.005$ ). For all surgical classifications except general surgery, readmission was independently associated with type of admission and need for mechanical ventilation. Long-term mortality was higher among patients who were readmitted than among the total sample. Nevertheless, quality-of-life scores were the same for patients who were readmitted and patients who were not.

**Conclusion** The adverse effect of readmission to the intensive care unit on survival appears to be long-lasting, and predictors of readmission are scarce. (*American Journal of Critical Care*. 2012;21:e120-e128)

According to the Quality Indicators Committee of the Society of Critical Care Medicine, readmission within 48 hours is a leading performance indicator of the quality of care in an intensive care unit (ICU).<sup>1</sup> However, factors that differentiate an appropriate readmission rate from factors associated with poor quality of care have not been evaluated. Thus, timely identification of ICU patients who are at high risk for readmission is important.<sup>2-5</sup> Readmitted patients are most often the sickest patients in the ICU. The association between readmission and patients' characteristics such as age, sex, and underlying disease during the first admission has been studied.<sup>6-15</sup> However, the association between different surgical conditions and ICU readmission has yet to be addressed. Moreover, the outcomes of patients readmitted to a surgical ICU have not been well described.

In this study, our first objective was to determine which factors, measured during a first surgical ICU admission, are independently associated with readmission to the unit. Our second objective was to compare the long-term (>10 years) survival and quality of life of surgical patients who were or were not readmitted to the ICU.

## Methods

In this prospective observational cohort study, all 1979 consecutive surgical patients admitted to the ICU at St Elisabeth Hospital, Tilburg, the Netherlands, a 673-bed teaching hospital, were included in the cohort. The duration of the study was 61 months, from January 1995 until February 2000. The 32-bed ICU admits medical and surgical critically ill patients and is staffed by critical care specialists with an internal medicine, anesthesiological, or surgical background. The study was part of a continuous quality improvement program (1995-2000) and was approved by the local medical ethics committee.

## Patients

Because the surgical population is a distinct ICU population, in both admission profile and outcome,

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patients in specific surgical subspecialties—trauma, vascular, gastrointestinal, oncological, and general—were the focus of the study. Exclusion criteria were age less than 18 years, readmission more than 30 days after first ICU discharge, and gynecological and nontrauma neurosurgery. Demographic data were collected on all patients: sex, age, type of surgical classification, severity of illness as indicated by the score on the Acute Physiology and Chronic Health Evaluation (APACHE) II<sup>16</sup> and the Simplified Acute Physiology Score (SAPS) 3<sup>17,18</sup> any preadmission disease (as scored in the chronic health points of the original APACHE II and comorbid conditions), elective or emergency admission, whether the admission was postoperative, type (indication) of first ICU admission, and lengths of first ICU and hospital stay. The APACHE II score was calculated in accordance with the original definitions (specific coefficients for diseases) by using the worst physiological values as measured during the first ICU day.<sup>16</sup>

Indications for admission were categorized as low-risk monitoring (admission for monitoring and observation), high-risk monitoring (patients in stable condition but with high risk of complications and need for extended care), and active treatment (patients with unstable conditions and need for continuous medical intervention). Initial ICU length of stay was defined as the period from the day of the first admission until the day of discharge from the unit. Length of (initial) hospital stay was defined as the period from the day of hospital admission until definitive discharge from the hospital, including the initial ICU admission and eventual readmission periods.

Readmission within 48 hours is a leading performance indicator of the quality of intensive care.

All consecutive surgical intensive care unit admissions in a 5-year period were included.

## Outcomes

Readmission to the ICU was defined as a return within 30 days (early or late readmission,  $\leq 48$  or  $> 48$  hours, respectively), internationally defined as ICU readmission after discharge from original ICU admission. The mean hospital length of stay was 25 days.

Survival was determined by reviewing the hospital's electronic patient medical record. If a patient's death could not be confirmed by the database, the patient's general practitioner was consulted. If a date of death could not be found, the patient or his or her relatives were consulted. Follow-up of each (surviving) patient was continued until February 2006. All patients were followed up for at least 6 years (mean, 8.4 years; SD, 1.4 years). A total of 52 patients were lost during follow-up (the follow-up rate was 97%). Quality of life was measured in all patients (those readmitted and those with a single admission) who were alive at the end of follow-up, February 2006. The EuroQol-6D questionnaire<sup>19-24</sup> (EQ-6D) was used to measure quality of life. The first EQ-6D outcome (EQ-utility score) was obtained by using the United Kingdom EQ-5D index tariff for all possible health states defined by the EQ self-classifier.<sup>25-27</sup> The cognitive dimension was ignored (not yet available for analysis). This index tariff links a single index value to each hypothetical health state.<sup>25</sup> The second outcome was the percentage of problems for each dimension. The outcome categories (no problems, mild problems, and severe problems) of these dimensions were dichotomized to no problems and problems (mild or severe).

## Data Analysis

A total of 16 patients had a missing value on either the APACHE II or SAPS 3. For these patients, the mean value was imputed by using linear regression analysis based on age, sex, and type of surgery. This method differs from the approach of Knaus et al,<sup>16</sup> who used normal values for missing data.

The incidence of ICU readmission within 30 days after first ICU discharge was measured. Data on patients who died during first ICU stay or 30 days or less after the original ICU discharge were excluded because these patients might have died before readmission. Subsequently, multivariable logistic regression analysis was used to determine the independent association of patients' characteristics with ICU readmission. Age, APACHE II score and SAPS 3 value were included as linear parameters, after cubic spline analysis confirmed the linearity.<sup>28</sup>

Short-term, ICU, and long-term survival were compared between patients who were readmitted and those who were not by using the Pearson  $\chi^2$  test. The quality-of-life outcome was compared by using the nonparametric Mann-Whitney test (EQ-utility score variable) and the Pearson  $\chi^2$  test (percentage of reported problems, dichotomized value). Cox regression modeling was used to generate survival curves.

Values of  $P < .05$  were considered significant. Statistical analysis was performed by using SPSS 15.0 (IBM SPSS) for Microsoft Windows XP Professional, version 2002, service pack 2.0.

## Results

The baseline characteristics of the total sample are given in Table 1. Of these 1979 patients, 297 died during their initial ICU admission or within 30 days after discharge from the ICU. Of the 1682 surviving patients, 141 (8%; 95% CI, 5-14) were readmitted to the ICU within 30 days after discharge. Readmission rates were 14% (95% CI, 11-19) for gastrointestinal (35/244), 10% (95% CI, 10-13) for vascular (55/538), 9% (95% CI, 8-11) for oncological (29/316), 4% (95% CI, 3-5) for trauma (15/422), and 4% (95% CI, 4-7) for general surgery (7/162) patients. Most of these patients (83%) were readmitted within the first 2 weeks (Figure 1). A total of 28 patients were readmitted within 48 hours (1.7% of the total cohort of 1682 patients; 20% of all patients readmitted). Causes of readmission were respiratory failure (68 patients, 48%) cardiac problems (16%), sepsis (14%), reoperation (11%), and other reasons (10%).

## Predictors of Readmission

Compared with patients who were not readmitted, patients who were readmitted were older, mostly had vascular (39%) or gastrointestinal surgery (25%), had a significant higher initial severity-of-illness scores (APACHE II: mean 12; SD, 6; vs mean, 11; SD, 6;  $P = .007$ ; SAPS 3: mean, 46; SD, 12 vs mean, 42; SD, 13;  $P = .003$ ), and had more comorbid conditions (14% vs 8%;  $P = .005$ ). In addition, more patients who were readmitted required more intensive care at the initial admission (low-risk monitoring: 49% of readmitted vs 63% of not readmitted,  $P = .001$ ; high-risk monitoring: 34% vs 27%,  $P = .09$ ; active treatment: 17% vs 10%;  $P = .004$ ; Table 1). Patients readmitted within 48 hours were significantly older, had more comorbid conditions, had higher initial severity-of-illness scores (SAPS 3), and more often received mechanical ventilation than did patients readmitted more than 48 hours after the latter patients' initial ICU admission. In the various

**Table 1**  
Baseline characteristics of the overall cohort and of patients who were or were not admitted

Characteristic	Total	Deceased <30 days	No readmission	Readmission	P
No. of patients	1979	297	1541	141 (8)	<.001
Age, mean (SD), y	60 (18)	65 (17)	58 (18)	65 (15)	.65
Male sex, %	66	65	67	64	.005
Comorbid conditions, <sup>a</sup> %	10	19	8	14	.17
Surgical classification, No. of patients (%) <sup>b</sup>					
Gastrointestinal	318 (16)	74 (25)	209 (14)	35 (25)	
Vascular	599 (30)	61 (21)	483 (31)	55 (39)	
Oncology	365 (18)	49 (16)	287 (19)	29 (21)	
Trauma	493 (25)	71 (24)	407 (26)	15 (11)	
General	204 (10)	42 (14)	155 (10)	7 (5)	
Initial admission severity scores, <sup>c</sup> mean (SD)					
APACHE II	12 (7)	18 (8)	11 (6)	12 (6)	.007
SAPS 3	45 (14)	58 (14)	42 (13)	46 (12)	.003
Readmission severity scores, mean (SD)					
APACHE II	ND	ND	ND	14 (8)	
SAPS 3	ND	ND	ND	52 (15)	
Emergency initial admission, %	47	63	56	58	.47
Admission directly after surgery, %	77	72	78	79	.60
Type of admission, %					
Low-risk monitoring	56	26	63	49	<.001
High-risk monitoring	29	37	27	34	.09
Active treatment	15	38	10	17	.004
Mechanical ventilation	36	73	30	32	.55
Dialysis, %	3	13	1	2	.29
Length of stay, median (25th-75th percentile), d					
In intensive care unit	2 (1-5)	3 (1-9)	2 (1-4)	2 (1-4)	.43
In hospital	13 (8-25)	9 (3-19)	13 (8-24)	36 (22-65)	<.001

Abbreviations: APACHE, Acute Physiology and Chronic Health Evaluation; ND, not done; SAPS, Simplified Acute Physiology Score.

<sup>a</sup> The presence of a preadmission disease (comorbid conditions, as scored in the chronic health points in the APACHE II).

<sup>b</sup> Percentages are based on the total number of patients listed as the first entry in each column. Because of rounding, not all percentages total 100.

<sup>c</sup> The APACHE II score ranged from 0 to 40 in our population. The SAPS 3 score ranged from 13 to 93.

surgical subspecialties, compared with patients who were not readmitted, only readmitted patients in the vascular (20% readmitted vs 10% not readmitted;  $P = .005$ ) and oncological (26% vs 6%;  $P = .001$ ) surgery groups had significantly more preadmission comorbid conditions. As indicated in Table 2, most surgical subspecialties (gastrointestinal, vascular, and oncological), higher level of care (high-risk monitoring and active treatment needed during initial admission), and need for mechanical ventilation were significantly independently associated with readmission.

### Outcomes of Patients Who Were or Were Not Readmitted

Short-term (ICU) mortality did not differ significantly between patients who were readmitted (10%) and those who were not (11%). Irrespective of its cause, the long-term mortality rate (6 years after ICU

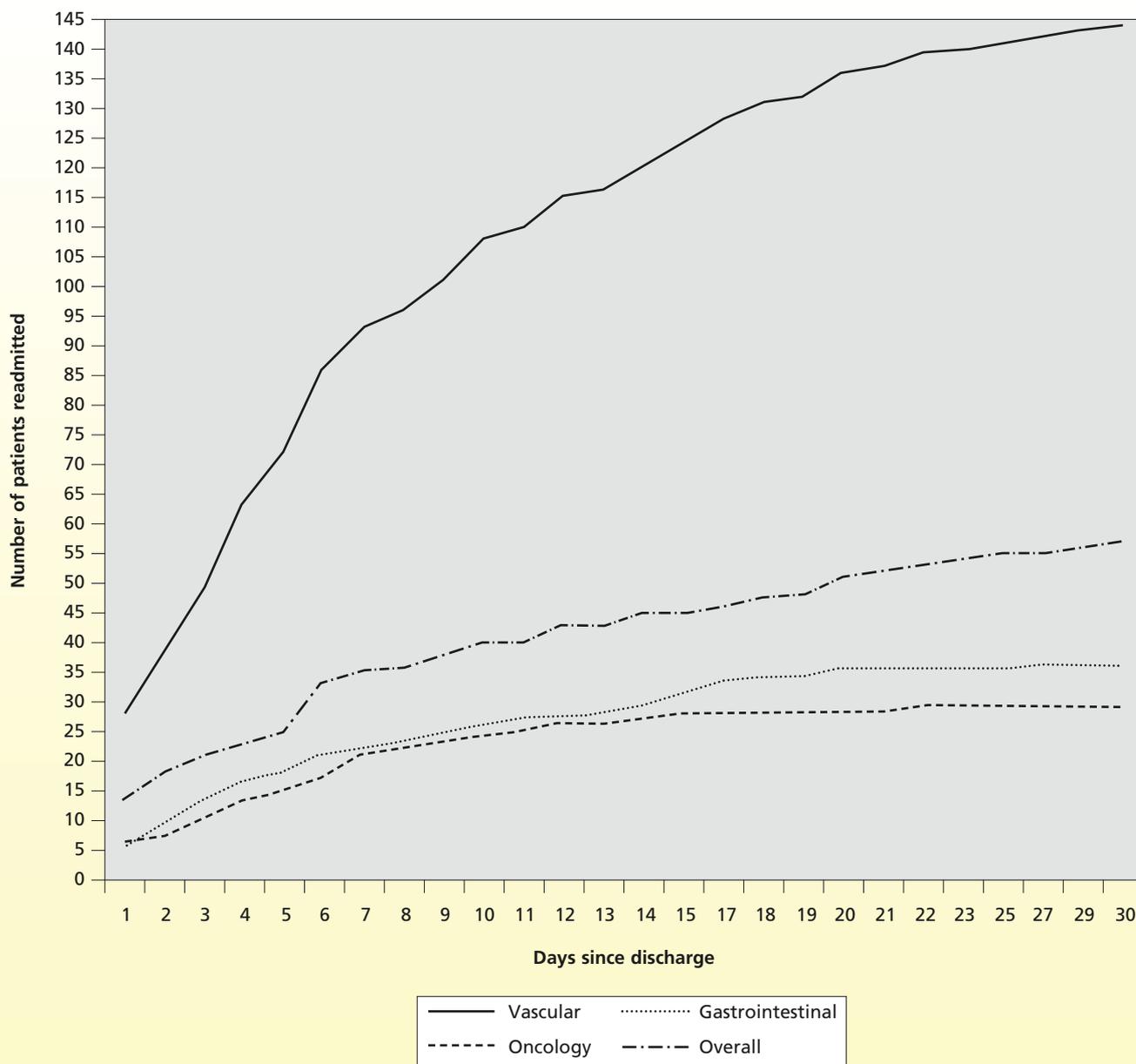
discharge) was significantly higher for patients who were readmitted (70% vs 42%;  $P < .001$ ; Figure 2).

Long-term mortality according to different surgical classifications was significantly higher for the gastrointestinal and vascular patients who were readmitted.

Of the 141 patients who were readmitted, only 43 survived until the end of the follow-up period. Quality of life (EQ-6D) was measured for 32 of these 43 patients (74%). Quality of life was also measured in 575 of the 886 patients (65%) who were not readmitted. As shown in Table 3, the median EQ-utility score and the percentage of reported problems did not differ significantly between the 2 groups of patients.

### Discussion

During a 5-year study period, 141 of 1979 surgical ICU patients (8%) were readmitted to the unit within 30 days after discharge.



**Figure 1** Readmissions within 30 days after discharge from a surgical intensive care unit. Figures of trauma and general surgery patients are not shown because of the low numbers of patients readmitted to the surgical intensive care unit: 15 patients and 7 patients, respectively.

Compared with patients who were not readmitted, those who were readmitted were older, had a higher prevalence of preadmission disease (comorbid conditions), had worse initial SAPS 3 values, and required more intensive treatment than monitoring only during the initial admission. Our results did not indicate any predictive variable for readmission at the beginning of the initial ICU admission. We found an independent association with readmission for all surgical classifications (except general surgery), admission type, and the need for mechanical ventilation. Most readmissions were due to respiratory

distress and occurred within the first 2 weeks after discharge from the ICU. A total of 28 patients (1.7%) were readmitted within 48 hours of discharge. These patients were significantly older, had more comorbid conditions, had higher initial severity-of-illness scores, and received mechanical ventilation more often than did patients readmitted more than 48 hours after the latter patients' initial ICU admission. More than 80% of readmitted patients had been discharged from the ICU for a period longer than 48 hours. Except for trauma and general surgical patients, patients who were readmitted had significantly

higher severity-of-illness scores at readmission than they did at their initial admission.

Patients who required readmission had a significantly worse long-term outcome than did patients who were not readmitted. Morbidity of the surviving readmitted patients was less than an age- and sex-matched general population norm.<sup>19,20</sup> The EQ-utility score did not differ significantly between patients who were readmitted and those who were not.<sup>19</sup>

Our ICU readmission rate was comparable to the 3% to 13% (surgical ICU population) and 5% to 10% (mixed ICU) rates reported by other investigators.<sup>2,4,6-16</sup> The causes of readmission in our study are in accordance with the causes in many earlier reports.<sup>2,5,6-11,16,29</sup> In general, respiratory distress is the main cause for readmission to intensive care. Unlike Nishi et al,<sup>9</sup> we did not detect a decrease in readmissions for respiratory failure during the study period (Figure 2). Although the readmission rate because of sepsis or reoperation varied from year to year during the study, numbers were low for all groups.

Readmission to the ICU is an unexpected, unfavorable event for patients, patients' family members, and health care workers and is associated with a worse outcome than the outcome for patients who are not readmitted. In our study, patients were sicker at readmission than at their initial admission, as indicated by the SAPS 3 value. Our hospital mortality rate (16%) is lower than the 20% to 46% rates reported by other researchers.<sup>4-6,9-11,28,29</sup> Nevertheless, readmitted patients do have a longer hospital admission and a significantly worse long-term survival than patients who are not readmitted. Other research<sup>4,7-9,11-15,29,30</sup> has shown that early ICU readmission is associated with morbidity and mortality rates that are higher than the rates of patients who are not readmitted.

The question arises then of whether or not readmission could be an important quality indicator. Readmission might indicate that the readmitted patients were discharged prematurely. If the patients were discharged too soon, the incidence of early readmission must be high. Of all the patients readmitted in our study, 20% were admitted early ( $\leq 48$  hours after ICU discharge). This percentage is slightly lower than published rates of 22% to 30%.<sup>3,5,7,29</sup> Moreover, a performance quality indicator requires a certain number of patients.<sup>2,6</sup> Our early readmission rate of nearly 2% (of the total study population) is probably not sufficient for a performance quality indicator. The relation between quality of care and late readmission (most of our study population) is questionable. Late readmission could be an indication of pathophysiological disturbance in a patient

**Table 2**  
Independent association of sex, age, surgical classification, comorbid conditions, type of admission, APACHE II score, SAPS 3 value, emergency admission, and use of mechanical ventilation with readmission, based on multivariable logistic regression

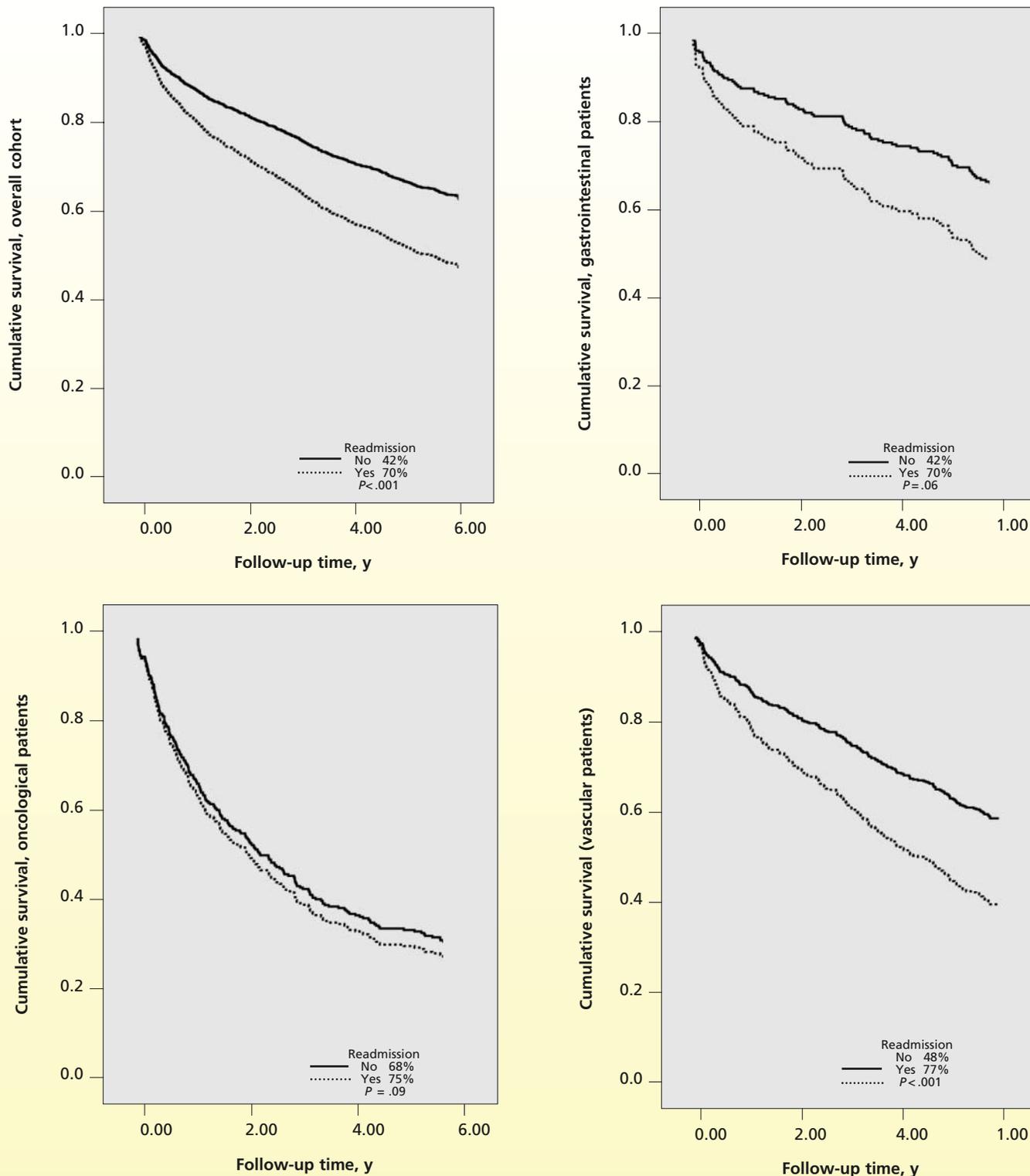
	Odds ratio	95% CI	P
Sex	0.97	0.66-1.42	.89
Age (per life year)	1.01	1.00-1.03	.16
Surgical classification			<.001
Gastrointestinal	4.21	2.04-8.70	<.001
Vascular	2.91	1.39-6.11	.005
Oncological	2.48	1.16-5.33	.02
General	1.23	0.46-3.31	.67
Trauma <sup>a</sup>			
Comorbid conditions	1.47	0.85-2.54	.17
Type of admission			<.001
Low-risk monitoring <sup>a</sup>			
High-risk monitoring	2.56	1.60-4.09	<.001
Active treatment	3.96	2.12-7.39	<.001
APACHE II (for each value)	1.02	0.97-1.07	.42
SAPS 3 (for each value)	1.00	0.97-1.03	.80
Emergency vs elective	0.89	0.54-1.47	.70
Mechanical ventilation	1.79	1.03-3.11	.04
Dialysis	0.63	0.17-2.49	.50

Abbreviations: APACHE, Acute Physiology and Chronic Health Evaluation; SAPS, Simplified Acute Physiology Score.

<sup>a</sup> The trauma patient group is the comparison group within the multivariable logistic regression for surgical classification; for type of admission, the low-risk monitoring group is the comparison group within the regression analysis.

with an underlying disease or comorbid condition. Although early readmission may be related to the initial cause for ICU admission, late readmissions most likely are related to factors beyond initial ICU control. Hypothetically, these readmissions are more likely to be a second ICU admission for a separate or additional problem rather than a true readmission. Nevertheless, Chen et al<sup>3</sup> evaluated the reasons for ICU readmission in patients readmitted within and after 24 hours and found no significant difference in the cause of readmission or the quality of care between the 2 groups.

Among the various surgical classifications, patients who had gastrointestinal and vascular surgery had a worse outcome (readmission incidence and long-term mortality) than did patients who had other types of surgery. Hypothetically, trauma patients are in better health before ICU admission than are patients with gastrointestinal or vascular problems. The cause of ICU admission (gastrointestinal and vascular patients) is not the same as comorbid conditions. Moreover, trauma patients are significantly younger than are patients in the other classifications.



**Figure 2** Survival curves (6 years) for patients who were and were not readmitted who survived the first admission to the surgical intensive care unit and readmission for the entire cohort and for gastrointestinal, vascular, and oncology patients.

Our study has several limitations. First, the data are from a cohort study done in a single center. However, the ICU and hospital (short-term) mortality

rates are almost identical to those in the Dutch National Intensive Care Evaluation<sup>31</sup> and are comparable to the rates in international ICU studies

from Finland,<sup>32</sup> Canada,<sup>33</sup> and the United States,<sup>34,35</sup> indicating a certain generalizability of our data. Although St Elisabeth Hospital is not a tertiary referral hospital, it is a level I trauma center and acts as a regional referral center for a population of 2.1 million people. Research by Dowdy et al<sup>36</sup> indicates that the prospective cohort study is a powerful research design for assessing relationships between exposures (ie, admissions, interventions, diagnostic tests) and ICU outcomes. A second possible limitation is that some data were collected retrospectively. However, the collection of in-hospital data and the survival status of individual patients were prospectively registered, and only 52 patients (3% of our entire cohort) were lost to follow-up. Compared with data in other studies,<sup>37-39</sup> this number is low. Furthermore, the presence of preadmission disease (comorbid conditions) was determined solely by using the chronic health evaluation component of the original APACHE II. Using this process, we detected no comorbid conditions in 1787 patients in the total study population (90%); this number could be an underestimation. This finding does not accurately take into account many disease states that may predispose patients to poor outcomes. The use of a different, more detailed scoring system might have yielded more specific information on the degree of comorbid conditions for the study cohort. At the same time, we determined the severity-of-illness score only at the beginning of an admission or readmission. Several investigators<sup>4,5,11,12</sup> found that readmitted patients had a higher severity-of-illness score at the time of the patients' original ICU discharge than did patients admitted only once. Therefore, our data would have been more valuable if we had collected the APACHE II score and the SAPS 3 value daily during the initial ICU admission. Currently, except for the study published by Lee et al,<sup>12</sup> little information<sup>6</sup> is available on how daily severity-of-illness scores change during ICU admission and therefore are predictive of discharge from the ICU. Lee et al concluded that the APACHE II score at the time of ICU discharge is a significant predictor of ICU readmission. Moreover, the APACHE II score has not been validated after the first 24 hours. This information may improve the ability to predict the readiness for discharge of individual surgical ICU patients and improve the efficiency of ICUs. In our study, patients who were readmitted had a worse long-term outcome than did patients who were not readmitted; however, quality of life did not differ significantly between the 2 groups. Only 141 patients were readmitted, and long-term quality-of-life information was available for only 32 patients.

**Table 3**  
**Outcome: cumulative long-term quality of life (at end of study period) for patients who were or were not readmitted to the surgical intensive care unit<sup>a</sup>**

	No readmission (n = 575)	Readmission (n = 32)	Mean/risk difference	P
EQ-utility score <sup>b</sup>	0.76 (0.62-0.88)	0.67 (0.59-0.88)	0.09	.08
Problems in dimension, %				
Mobility	52	69	17	.07
Self-care	20	31	11	.12
Usual activity	53	66	13	.20
Pain/disorder	57	59	2	.86
Anxiety/depression	29	38	9	.32
Cognition	43	31	12	.27

<sup>a</sup> Quality of life was measured in 575 of 886 nonreadmitted patients and in 32 of 43 readmitted patients alive at the end of the study period. Outcome scales of the EQ-5D+ dimensions were dichotomized from no problems, mild problems, and severe problems to no problems and problems.  
<sup>b</sup> EQ-utility score value in median with 25th and 75th percentile. Mean (SD) for readmitted group, 0.63 (0.30); nonreadmitted group, 0.71 (0.26).

The lack of a significant difference might reflect a type I error due to the small sample size of readmitted patients and might lead to false-negative results, because we noticed a tendency for a worse quality of life for patients who were readmitted.

Use of early readmission as a quality indicator is difficult. Further research into this topic should include multiple centers/ICUs and comparisons of low performers with high performers, with regard to quality of intensive care treatment provided.

In conclusion, the adverse effect that readmission to the ICU has on survival appears to be long lasting. Patients who were readmitted had a worse long-term survival than did patients who were not readmitted. In addition, patients who were readmitted had worse initial severity-of-illness scores, had a higher prevalence of preadmission disease (comorbid conditions), and required more active treatment during their initial ICU admission. Possibly, the higher long-term mortality is associated with the higher prevalence of comorbid conditions and not with readmission. Although no single (ICU admission) factor was independently predictive of readmission, hypothetically, the conditions predisposing a patient to initial admission to an ICU, not the need for readmission, are responsible for the patient's long-term outcome. Because of the design of our study, we cannot determine whether readmission is an independent prognostic factor of quality of care. The relationships between readmission to the ICU, inadequate care, premature or inappropriate discharge, and clinicians' decision-making practices require more study.

## FINANCIAL DISCLOSURES

None reported.

### eLetters

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