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Are there accurate predictors of long-term vital and functional outcomes in cardiac surgical patients requiring prolonged intensive care?

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Abstract

Background and objective: The decision to maintain intensive treatment in cardiac surgical patients with poor initial outcome is mostly based on individual experience. The risk scoring systems used in cardiac surgery have no prognostic value for individuals. This study aims to assess (a) factors possibly related to poor survival and functional outcomes in cardiac surgery patients requiring prolonged ($\geq$ 5 days) intensive care unit (ICU) treatment, (b) conditions in which treatment withdrawal might be justified, and (c) the patient's perception of the benefits and drawbacks of long intensive treatments. **Methods:** The computerized data prospectively recorded for every patient in the intensive care unit over a 3-year period were reviewed and analyzed (n = 1859). Survival and quality of life (QOL) outcomes were determined in all patients having required $\geq$5 consecutive days of intensive treatment (n = 194/10.4%). Long-term survivors were interviewed at yearly intervals in a standardized manner and quality of life was assessed using the dependency score of Karnofsky. No interventions or treatments were given, withhold, or withdrawn as part of this study. **Results:** In-hospital, 1-, and 3-year cumulative survival rates reached 91.3%, 85.6%, and 75.1%, respectively. Quality of life assessed 1 year postoperatively by the score of Karnofsky was good in 119/165 patients, fair in 32 and poor in 14. Multivariate logistic regression analysis of 19 potential predictors of poor outcome identified dialysis as the sole factor significantly (p = 0.027) – albeit moderately – reducing long-term survival, and sustained neurological deficit as an inconstant predictor of poor functional outcome (p = 0.028). One year postoperatively 0.63% of patients still reminded of severe suffering in the intensive station and 20% of discomfort. Only 7.7% of patients would definitely refuse redo surgery. **Conclusions:** This study of cardiac surgical patients requiring $\geq$5 days of intensive treatment did not identify factors unequivocally justifying early treatment limitation in individuals. It found that 1-year mortality and disability rates can be maintained at a low level in this subset of patients, and that severe suffering in the ICU is infrequent.

Keywords: Cardiac surgery; Treatment withdrawal; Early and late survival; Quality of life; Predictors of poor outcome; Dialysis; Sustained neurological deficit

1. Introduction

Large series report less than 5% mortality and 25–45% complications after heart surgery [1,2]. In-hospital mortality is linked with considerable but timely limited human and financial consequences. In contrast, the burden of severe long-term disability persists over time. At the present time, patients in disastrous cardiac and general condition are increasingly referred for cardiac surgery. These patients are at risk of prolonged intensive care unit (ICU) treatments. Obviously, only low in-hospital and mortality rates as well as a fair quality of life (QOL) in long-term survivors can justify the human and socio-economical consequences of these treatments. Therefore, cessation of life-supporting measures must be considered whenever treatment becomes futile or is opposed to patient and family wishes. However, various lines of evidence indicate that the approach of end-of-life decisions differs considerably among healthcare workers [3–5], that individual experience is selective and influenced by recent or anecdotal cases [6], and that the physician's opinion tends to prevail over that of patients [7].

The risk-scoring systems commonly used in cardiac surgery are chiefly based on preoperative risk factors and, thus, not able to identify changing mortality and morbidity risks in patients with unexpected perioperative complications. Moreover, these systems have been developed to improve operative decisions as well as quality comparisons and cost–benefit analysis [8]; their predictive value is much higher for groups than for individuals [8–10]. None of these scores has been conceived for end-stage prospective decisions or to facilitate decisions about individuals [9]. The recent comparison of six

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scoring systems commonly used in heart surgery has also evidenced the poor predictive value of each of these scores for morbidity [10]. Hence, at present time, the decision to limit treatment in cardiac surgical patients with apparently poor recovery expectancy is based on experience instead of evidence.

The objectives of this study are, first, to identify factors possibly related to poor prognosis in cardiac surgical patients with difficult initial outcome, second, to identify conditions in which treatment withdrawal might be justified and, third, to assess the patient's perception of the benefits and drawbacks of long ICU treatments.

2. Patients and methods

2.1. Settings and routine procedures

The CHUV is an 870-bed teaching hospital with a single surgical ICU of 17 beds and a high patient turnover. The cardiac surgical department has six fully monitored intermediate care beds; telemetry is available on the ward. Patients operated on cardiopulmonary bypass (CPB) are routinely admitted in the ICU and discharged to the intermediate cardiac surgical care unit within 24—36 h unless they further require mechanical ventilation, intra aortic balloon pump (IABP) and/or important inotropic support (either any dose of milrinone [Corotrop® Sanofi-Synthélabo, Paris, France] or Dopamine [Dopamin® B. Braun, Melsungen, Germany]/Dobutamine [Dobutrex® Lilly, Indianapolis, USA] in excess of 8 μg/(kg min) or over 10 μg/(kg min), norepinephrine [Noradrenaline® Sintetica SA, Mendrisio, Switzerland]). Patients with deteriorating renal function are kept in the ICU until blood creatinin has peaked or until renal replacement therapy has been initiated.

In conformity with the recommendations of the SUPPORT study [11], conscious patients and families receive frequent information on present condition and prognosis; they are included in discussions on major treatment decisions. No interventions or treatments were given, withhold, or withdrawn as part of this study.

2.2. Data collection

Cardiac surgical patients having required ≥5 consecutive days in the ICU over a 3-year period were identified from the ICU database. Heart transplant recipients and patients with cardiac tumors were excluded. Nineteen among 44 parameters prospectively recorded for each patient as part of our clinical information system (Claris File Maker Pro v2.1) were selected as potential predictors of poor vital and functional outcomes:

- Patient-related factors: age, gender, ejection fraction <30%, neurological impairment (defined as a disease severely affecting day-to-day functioning or ambulation), chronic obstructive pulmonary disease (COPD) on bronchodilators, insulin-requiring diabetes, obesity (BMI > 30), dialysis-dependent renal failure, nature of surgical procedure, priority, and redo surgery.
- Operative-related factors: cross-clamp and CPB times.
- Life-supporting procedures: mechanical ventilator support ≥5 days, renal replacement therapy, IABP, surgical revision, cardiopulmonary resuscitation, and electrical counter shock for life-threatening arrhythmias.

The choice of these variables was founded on distinct criteria:

- Patient-related factors were selected from a review of three major risk scoring system for cardiac surgical patients: the Parsonnet score, the Euroscore, and the Society of Thoracic Surgeons (STS) national database. Significant variables in at least two systems were selected.
- Life-supporting procedures required by persistent life-threatening failure in one organ system were selected because this condition has been shown to chiefly determine the patient's outcome [12—15].
- Ischemic and CPB times were included in the analysis because of their unquestionable deleterious effects on both physiology and the clinical outcome [16].

2.3. Investigations

A single independent physician collected all follow-up data. Patients and, whenever necessary, their relatives and home practitioners were interviewed by phone 1, 2, and 3 years after surgery. This interview was based on both the dependency score of Karnofsky [17] and a simplified version of the SF 12 TM Health Survey, allowing collection of standard information on:

- persistent disabilities and/or need for assistance,
- complications and diseases after hospital discharge,
- physical condition 1 year postoperatively,
- psychological condition 1 year postoperatively,
- self-assessed quality of life,
- difference between preoperative and present general condition (improved, stable, worsened),
- frequency and severity of discomfort and pain during ICU treatment, and
- attitude towards a hypothetical redo operation.

2.4. Outcomes

Main outcome measurements included: (a) early mortality, defined as any mortality occurring in the hospital or within 30 days, (b) annual postoperative mortality rate over 3 years, (c) degree of disability 1 year postoperatively, and (d) quality of life 1 year after surgery.

The dependency score of Karnofsky (Table 1) allowed differentiating between patients with optimal (K 100) or good (K 90) recovery after 1 year and those with any kind of persistent disability ($K \leq 80$), regardless of their preoperative condition.

2.5. Characteristics of follow-up

Follow-up of hospital survivors ranged from 12 to 48 months (average 30 months corresponding to 485 patient-years). The response rate for the first interview reached 98.8%; missing data (two patients) were censored at hospital discharge.

Table 1
Main features of the Karnofsky Performance Status [14]

K value	Performance
100	No complaints or evidence of disease
90	Normal activity, minor signs of disease
80	Normal activity with effort, signs of disease
70	Selfcare, unable to carry out normal activities or to work
60	Assistance needed, able to care for most of own needs
50	Requires considerable assistance and frequent medical care
40	Disabled, requires special care and assistance
30	Severely disabled
20	Supportive treatment necessary
10	Moribund

2.6. Statistical analysis

Descriptive statistics were used to summarize the demographic and clinical characteristics of the population. Values are given as mean ± SD. Two major outcomes of interest were considered for comparative analysis: the survival and the long-term dependency. Differences between continuous variables were assessed by the unpaired Student's *t*-test. Categorical variables were compared using the χ^2-test. All tests were two-tailed and *p* values $\leq$0.05 were considered significant. Finally, suitable parameters were considered for a multivariate logistic regression analysis to identify independent risk factors. Analyses were performed using the statistical software package JMP 3.1 (SAS Institute Inc., Cary, NC, USA).

3. Results

Of the 1859 consecutive adult patients operated on cardiopulmonary bypass over a 3-year period in a single institution, 194 (10.4%) required 5–22 consecutive days of ICU treatment (mean 7.5 ± 3.4 days, median 7 days). The risk profile of these patients and the distribution of the surgical procedures are detailed in Tables 2 and 3. Table 3 shows that the risk of long ICU stay depends mostly on the complexity of the surgical procedure. Oppositely, neither high surgical priority (9.8% of patients in the prolonged group received urgent (*n* = 12) or emergent (*n* = 7 surgery)) nor cross-clamp and CPB times (80 ± 33 min and 122 ± 53 min, respectively, in the prolonged group) was significantly correlated with long ICU treatment.

3.1. Mortality

(1) Early mortality: Of the 194 patients in the study group, 17 (8.75%) died in the hospital or within 30 days. The causes of these deaths were as follows: cardiogenic (*n* = 8) or septic shock (*n* = 3), pulmonary embolism (*n* = 3), rhabdomyolysis (*n* = 1), and support withdrawal (*n* = 2) at postoperative day 6 and day 9, because of poor expected outcome after devastating stroke in the first case and large mesenterial infarction in the second one. In comparison, the mortality among the 1655 cardiac surgical patients having required shorter ICU treatment during the same period of time was 2.0% ($p < 0.001$). Table 4 details the influence of various life-supporting measures on mortality. Prolonged assisted ventilation, renal replacement therapy, surgical revision and, to a less extent, intra aortic balloon pump were all associated with increased 30-day mortality. However, only dialysis ($p < 0.001$) and prolonged ventilation ($p < 0.01$) emerged as independent predictors of early death. ICU length of stay for non-survivors despite ongoing full ICU treatment averaged 10.6 ± 5.2 days; if life support had been withdrawn at the fifth ICU day in all patients who ultimately died in the hospital, only 96 days of ICU resources would have been saved.
(2) Mid-term survival: Nineteen of the 177 early survivors died during follow-up, which accounts for cumulative survival rates of 85.6%, 80.9%, and 75.1% at 1, 2, and 3 years, respectively. The causes of late deaths are presented in Table 5. Neither the gender nor the type of surgical procedure, CPB and aortic cross-clamping times were significantly related to mortality outcomes. Age above 75 years was associated with lower ($p = 0.05$) mid-term survival (Table 6). However, seven out of eight fatal events in these elderly patients occurred more than 1 year postoperatively, and four deaths were not clearly related to previous cardiac and ICU treatment (two cancers, one traffic accident, one vascular amputation).

Table 2
Preoperative risk factors of 1859 CPB patients

Variable	≥5 ICU days (194 patients)	<5 ICU days (1655 patients)	*p*
Female	34%	23.2%	<0.01
Age (years)			
Mean ± SD	66.1 ± 10.7	61.0 ± 8.4	
Median/range	68.0/20–83	62.5/17–88	
18–55 years	12.8%	29.6%	<0.001
56–70 years	45.4%	51.1%	ns
>70 years	41.8%	19.3%	<0.001
LV ejection fraction <30%	12.4%	7.1%	<0.05
Insulin diabetes	8.2%	4.0%	ns
COPD under bronchodilators	8.7%	7.1%	ns
Obesity (BMI > 30)	17.5%	20.8%	ns
Chronic dialysis	3.1%	0.7%	<0.01
Previous stroke	2.6%	3.7%	ns
Redo operations	3.1%	8.4%	<0.01

LV: left ventricular; COPD: chronic obstructive pulmonary disease.

Table 3
Surgical procedures

Procedure	Number	ICU ≥5 days	Percentage	Males	Females
CABG	1179	100	8.5	71	29
Valves	330	26	7.9	12	14
CABG + valve(s)	144	41***	28.5	27	14
Thoracic aorta	58	8	13.8	7	1
Adult congenital	69	0	0	0	0
Combined procedures[a]	79	19***	24.1	14	5
Total	1859	194	10.4	131	63

CABG: coronary artery bypass graft.
[a] Cardiac and non-cardiac procedures during the same session.
*** $p < 0.001$.

Table 4
Influence of various life-supporting procedures on early and mid-term mortality rates

Procedure	30 days mortality (with/without)	p	Late mortality (with/without)	p	Overall mortality (with/without)	p*/•
Ventilation ≥5 days	14/70 versus 0/124	***/•••	4/56 versus 18/124	ns	18/70 versus 18/124	ns
Dialysis	9/24 versus 5/170	***/••	1/15 versus 21/165	ns	10/24 versus 26/170	**/••
IABP*	6/30 versus 8/164	*	0/24 versus 22/156	ns	6/30 versus 30/164	ns
Reoperation	8/34 versus 6/160	***	2/26 versus 20/154	ns	10/34 versus 26/160	ns
Resuscitation	4/33 versus 10/161	ns	3/29 versus 19/151	ns	7/33 versus 29/161	ns
Defibrillation	3/24 versus 11/170	ns	3/21 versus 19/159	ns	6/24 versus 30/170	ns

IABP: intra aortic balloon pump.
* = χ^2-test.
• = Logistic regression analysis.
*/• $p < 0.05$.
**/•• $p < 0.01$.
***/••• $p < 0.001$.

(3) Overall mortality: Dialysis-dependent renal dysfunction was the sole factor detrimentally affecting overall survival in the study group ($p < 0.01$). Nonetheless, 60% of the 24 patients having required any kind of renal replacement therapy after surgery (including six patients with preoperative chronic dialysis) were still alive and in a fair to good condition 1 year later.

3.2. Neurological complications

Twelve (6.2%) severe neurological complications occurred in the hospital: 11 strokes (one fatal) and one paraplegia. All occurred within 7 days of the operation.

3.3. Return in the ICU

Seven patients (4%) needed to be readmitted in the ICU because of respiratory failure ($n = 4$), severe heart failure ($n = 2$), and redo sternotomy for mediastinitis ($n = 1$). All survived and were discharged from the ICU within 3–11 days.

Hospital readmission within 1 year occurred in 19 one-year survivors (12%). It was unpredictable in nine patients suffering from cardiac failure ($n = 4$), pneumonia ($n = 2$), late stroke ($n = 1$), severe chest pain ($n = 1$), and trauma ($n = 1$). Furthermore, two patients received non-emergent surgery for non-related diseases. Oppositely, readmission had been planned before the heart operation in eight patients with concomitant cardiac and non-cardiac diseases (two aortic aneurysms, three cancers, three joint disease).

3.4. Quality of life

Functional and subjective results 1 year postoperatively were obtained from 165 of the 167 survivors (Fig. 1). Seventy-two percent had no physical symptoms or minimal physical symptoms (*K* scores of 100 and 90), 19% had signs of disease (*K* score of 80) but no important limitations of their activity, 6% were disabled (*K* score of 70–50), and 3% were severely handicapped (*K* score < 50). Disability, defined by *K* score less than 80, was neither significantly related to ICU treatments (Table 7) nor to patient profile, CPB and cross-clamp times or type of surgery. The sole predictor ($p < 0.05$) for a lasting QOL deterioration was the occurrence of a perioperative neurological accident. Conversely, perioperative neurological events were implicated in 11 of the 14 cases of long-term disability.

At 1 year, 132 patients (80%) considered themselves in better condition as compared to their preoperative situation, 19 felt no change (11.5%) and 14 reported a degradation of their general living conditions (8.5%). However, deterioration was obviously related with previous in-hospital treatment in only nine cases (four chronic cardiac failures, two severe residual chest pain, two strokes, and one paraplegia); in the remaining five cases deterioration was caused – or worsened – by intercurrent diseases (two cancers, two vascular amputations, one disabling arthrosis). Oppositely, 15 patients reported global improvement in spite of substantial postoperative sequelae such as eight persistent neurological deficit, two severe residual chest pain, one tracheal stenosis after tracheotomy, one limb claudication after intra aortic

Table 5
Delay and cause of 19 late deaths after prolonged ICU treatment

Cause of death	1–6 months	7–12 months	13–18 months	19–24 months	25–30 months	31–36 months	<36 months	Total (disease)
Cancer	1	2	1	1	0	1	0	6
Heart failure	1	3	0	0	0	0	0	4
Vascular disease	0	1	1	0	0	0	0	2
Septic shock	0	1	1	0	0	0	0	2
MOF	0	0	1	0	1	0	0	2
Bleeding	0	0	1	0	0	0	0	1
Trauma	1	0	0	0	0	0	0	1
Unknown	0	0	0	0	0	0	1	1
Total/period	3	7	5	1	1	1	1	19

MOF: multiple organ failure.

Table 6
Influence of age on early and mid-term mortality

Age (years)	Number of patients	In-hospital deaths	Percentage	Mid-term deaths (1–48 months)	Percentage	Total	Percentage
<40	6	0	0	0	0	0	0
41–45	2	1	50	0	0	1	50
46–50	8	2	25	0	0	2	25
51–55	9	1	11	0	0	1	11
56–60	21	0	0	2	9.5	2	9.5
61–65	36	4	11	2	5.6	6	16.5
66–70	31	3	9.5	4	12.9	7	22.5
71–75	45	4	9.0	3	6.7	7	15.5
>75	36	2	5.5	8*	22.2	10	27.8

* $p < 0.05$ versus mid-term death in patients <75 years of age.

balloon pump, two worsening of a shoulder arthrosis, and one deterioration of multiple sclerosis.

From a socio-economic point of view, most patients lived at home without any assistance (89.4%) or with (6.4%) help of relatives, while a small minority had to be placed in nursing homes (3%) or remained hospitalized (1.2%).

3.5. Pain and discomfort

The burden of ICU treatment could no longer be accurately quantified 1 year after discharge but important pieces of information could still be collected: Despite an apparently liberal use of opioids and sedatives, one patient (0.6%) still reminded of severe pain and 33 others (19.8%) of discomfort due to: permanent noise and illumination ($n = 17$), recurrent nightmares for months ($n = 12$), panic ($n = 2$), conflict with the nursing staff ($n = 1$), and amnesia ($n = 1$). Indeed, after such a long period of time, 85% of these discomforts were rated minor by the patients. Accordingly, 81.4% of survivors stated that they would accept redo surgery if necessary, 10.9% would hesitate, and only 7.7% would definitely refuse.

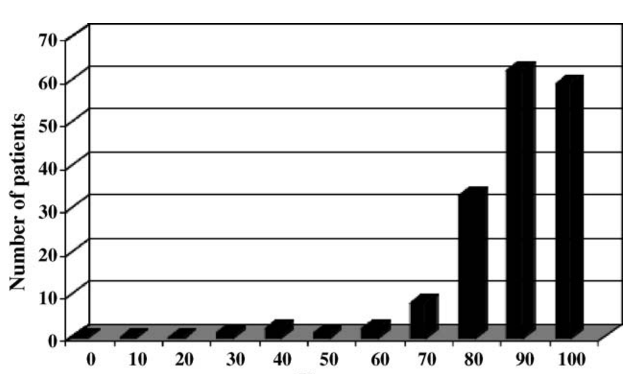

Fig. 1. Distribution of *K* scores in 165 one-year survivors.

4. Discussion

Reliable prognostic information and the patient perception of his situation have been found the most important factors for physicians facing life-support decisions for critically ill patients [11]. Our study has documented the absence of reliable predictive factors of ominous survival or functional outcomes in cardiac surgical patients requiring ≥5 days of ICU treatment.

There is no consensus on the definition of prolonged ICU treatment. The following issues have guided our choice of 5 days: (A) The analysis of end-of-life practices in 31,417

Table 7
Influence of various life-supporting procedures on late functional outcome measured by the *K* score 1 year after discharge

Procedure	*K* score 30–80 (with vs without)	p^*
Ventilation ≥5 days	12/39 versus 34/126	ns
Dialysis	3/14 versus 43/151	ns
IABP	5/24 versus 41/141	ns
Reoperation	7/24 versus 39/141	ns
CPR	6/28 versus 40/137	ns
Defibrillation	3/20 versus 43/145	ns

IABP: intra aortic balloon pump; CPR: cardiopulmonary resuscitation.
* = χ^2-test.

general patients from various European ICUs [4] found a median ICU stay of 4 days and a median delay of 2.8 days until the first treatment limitation was decided. (B) It has been established that the worst ICU patients tend to die within 5 days [13]. (C) ICU mortality remains elevated for several weeks: the SUPPORT study [11] found a median number of 14 ICU days before death among surgical patients. (D) All cardiac patients still under ICU treatment at the fifth postoperative day have at least one severe organ system failure [18]; at this time the risk of poor outcome depends much more on the evolution of this organ failure than on preprocedural patient risk factors [19]. (E) Decisions of treatment withdrawal need to be founded and limited to patients with no chance of decent recovery; several days of full treatment allow accurate estimation of the patient's overall prognosis and response to treatment; moreover, full treatment for several days helps convincing the patient's surrogates that money saving is not the actual reason for treatment withdrawal.

On the other hand, two recent studies [20,21] have concluded that outcome predictions based on organ dysfunction scores are not reliable during the first 14 days following cardiac surgery. Unfortunately, this delay makes decisions of treatment limitation much too late to substantially reduce the amount of unnecessary patient suffering and waste of medical resources.

Survival in this cohort of cardiac surgical patients requiring prolonged ICU treatment is higher than those predicted by nonspecific preoperative risk assessment systems; likewise, it compares favorably with the outcome of general ICU patients. These differences can be ascribed to the fact that cardiac surgical patients initially present with a correctible organ failure. The rather favorable mid-term outcomes and the high proportion of patients able to resume independent life (89%) demonstrate that prolonged ICU treatment does neither provoke an accumulation of mid-term medical disasters nor induces tremendous hidden socio-economical costs.

QOL is increasingly regarded as central to the definition of success [18,22], or even as the most important outcome of cardiac surgery [23]. Crude survival is considered a poor marker of treatment efficiency for two reasons: First, low mortality rates are linked with limited statistical power and, thus, not qualified for outcome-directed quality assessment studies [24]; second, patients with the worst preoperative condition are those who benefit more from the operation [2]. Unfortunately, however, QOL is an observer-dependent concept and the scores currently used to assess QOL scarcely take into account the patients opinion; moreover, it has been suggested that physicians tend to be too pessimistic regarding prognoses and to provide more extensive treatments than they would choose for themselves [11]. However, there are no indications from this study that prolonged ICU treatment produced major sufferings in a large number of patients, nor that survival was achieved at the expense of the patient's quality of life [19].

Unrelieved pain and discomfort are still known problems of ICU management: The SUPPORT study [11] found moderate to severe pain occurring at least half of the time in 12–32% of critically ill patients; self-assessment in real time by 100 cancer patients from various medical ICUs revealed pain and discomfort in nearly 75% of cases [25]. The low rate of complaints from our patients is mostly attributable to recall bias and minimization by patients interviewed for the first time 1 year after treatment. Nonetheless, these recalls still indicate that pain and discomfort have been managed but not eliminated; accordingly, further improvement in communication, patient comfort, as well as in analgesic and sedative therapies, are still needed. Finally, the emergence of noise and permanent lightening as the main source of discomfort underscores the absolute necessity to minimize these factors, especially at nighttime.

Resource consumption is another important issue of ICU treatment analysis. It has been reported that 13.3% patient days — and 16.7% of total ICU expenditure — are invested in non-survivors [14]. These figures do not apply for cardiac surgical patients: we found that treatment cessation at the fifth ICU day in all patients who ultimately died in the hospital would have reduced by 1.85% the ICU occupation time by cardiac surgery patients. A similar analysis by Holmes et al. [19] found comparable overall potential savings in ICU bed-days.

5. Limitations of the study

(1) Our main purpose was to identify possible predictors of poor outcome in operated cardiac patients requiring prolonged ICU treatment. Therefore, this study was not designed to allow refined comparisons between the pre- and the postoperative functional condition of cardiac surgical patients.
(2) The *K* score was chosen because it focuses on functional disability. More sophisticated QOL scoring systems measuring items such as emotional burden, poor social integration, family disturbances, or decreased sexual performances were considered not pertinent for treatment withdrawal decisions.
(3) A medium-sized single-center study allows avoiding bias induced by inhomogeneous concepts of treatment. It might be argued that a wide multicentric study could identify additional markers of poor outcome. However, systems needing a huge number of observations to reach significance may retain some prognostic value for cohorts, but they certainly do not fit for individual treatment withdrawal decisions. Moreover, it can be calculated that a sample size of over 32,500 patients would be necessary to evidence a relationship between risk factors occurring in around 3% of CPB patients — such as gastrointestinal complications or severe hematological disease — and a twofold increase in global mortality or disability rate. And, it must be considered that at present time patients who are at increased risk of bleeding are mostly operated off pump.

6. Conclusions

Accurate early predictors of poor vital and functional outcomes are still lacking for cardiac surgery patients requiring prolonged and complex ICU management. Acute neurological damage is the sole factor increasing the risk of long-term disability. In the initial phase of ICU treatment, prospect for functional improvement is still high. Therefore, several days of full ICU treatment should be allowed before treatment limitation is decided.

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