Body Mass Index and Outcome After Ventricular Assist Device Placement

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Background. **The implantation of ventricular assist devices (VAD) is an established treatment for end-stage congestive heart failure. Extremes of body mass index (BMI) are associated with decreased survival after cardiac surgery. Many patients with congestive heart failure develop cardiac cachexia. In this study the association between BMI and outcomes after VAD implantation was investigated.**

Methods. **Consecutive patients (n = 590) who underwent VAD placement between 1996 and 2006 were divided into five groups based on BMI (kg/m^2) quintiles (<20; 20–24; 25–29; 30–35; and >35). In a multivariate analysis adjusted for age, sex, diagnosis, emergency level, and type of device (left ventricular or biventricular assist device), procedural success (recovery, transplantation, or 30-day survival) and complications were analyzed. The best group was set as reference category for calculation of odds ratios.**

Results. **The groups with both extremes of BMI had the worst outcomes. The best procedural success was in the group with BMI 25 to 29 kg/m^2. Underweight patients had similar survival rates to patients with normal weight. Overweight and obese patients did not have decreased survival. Extreme obesity at the time of VAD implantation showed elevated risk for postoperative death. There was no significant difference for BMI groups in the type of complications and cause of death. Cumulative survival curves for BMI category and overall VAD patient survival showed no significant differences.**

Conclusions. **Cardiac cachexia need not be an exclusion criterion for VAD placement. Underweight patients appear to have benefit from mechanical support. Severely obese patients should be carefully selected before VAD placement.**

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End-stage heart failure patients are increasingly often without any effective therapeutic solution because of the limitations of pharmacologic therapy combined with the donor organ shortage for cardiac transplantation. Although criteria for the listing of transplant candidates vary depending on the center, severe obesity is considered a contraindication as a result of higher posttransplant mortality [1]. Nutritional factors such as low albumin identify patients at increased surgical risk, but low body mass index (BMI) actually need not be a contraindication for heart transplantation. Currently, ventricular assist devices (VADs) offer a "long" bridge to transplantation, and some of them are now approved for permanent support in patients who cannot be transplant candidates. The first randomized clinical trial assessing left ventricular assist device (LVAD) implantation as "permanent" therapy demonstrates that mechanical circulatory support can successfully address this need in highly selected patients, with significant survival benefit for LVAD recipients compared with standard pharmacologic therapy [2].

However, VAD implantation and subsequent care are expensive. To optimize the cost-effectiveness of this approach and minimize futile application, data are necessary on which to base the selection of VAD candidates with presumed acceptable outcomes. Malnutrition is generally recognized as a major risk factor for surgery [1, 3, 4] and might consequently be expected to influence efficacy of VAD therapy. Obesity is epidemic and is associated with worse perioperative outcome for surgical procedures in general [5] and with higher mortality rates after heart transplantation [6]. An association between BMI and VAD outcome has been described by only a few groups [7–9]. In this study, we assessed whether recipient BMI is correlated with the mortality and major morbidity among patients undergoing VAD implantation. With the high prevalence of overweight and obese patients in the developed countries, this issue is currently becoming extremely important.

Material and Methods

Population

The study population for this retrospective investigation consisted of 590 patients with advanced heart failure who underwent VAD placement between 1996 and 2006. Patients were divided into five groups based on their BMI quintiles distribution: BMI less than 20 kg/m^2; BMI 20 to

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Table 1. Baseline Patient Characteristics in Different Body Mass Index Groups

Characteristics	Overall (n = 590) (%)	BMI <20 kg/m² (n = 35) (%)	BMI 20–24 kg/m² (n = 247) (%)	BMI 25–29 kg/m² (n = 220) (%)	BMI 30–34 kg/m² (n = 72) (%)	BMI >35 kg/m² (n = 16) (%)	p Value
Age (y) mean ± SD	51.6 ± 12.3	45.8 ± 17.6	50.8 ± 12.6	52.9 ± 11.2	52.9 ± 10.5	51.8 ± 13.2	0.019
Male	85.9	74.3	83.8	91	86.1	75	0.027
Height (cm) mean ± SD	175.2 ± 8.2	175 ± 8.8	175 ± 8.4	176 ± 7.6	174 ± 7.6	171.2 ± 11.3	0.1
Weight (kg) mean ± SD	79.5 ± 14.9	56.1 ± 7.4	71.3 ± 8.9	84.6 ± 8.4	97.3 ± 9.5	112.2 ± 17.9	0.00
Body surface area (m²) mean ± SEM	1.95 ± 0.017	1.3 ± 0.04	1.7 ± 0.01	2.08 ± 0.01	2.3 ± 0.03	2.7 ± 0.13	0.00
BMI (kg/m²) mean ± SD	25.8 ± 4.2	18.2 ± 1.2	23.1 ± 1.3	27.2 ± 1.2	32 ± 1.3	38 ± 2.6	0.00
Dilative CMP	44.9	42.9	47.6	44.2	44	23.5	0.4
Ischemic dilative CMP	29.1	22.9	27.4	29.5	34.7	35.3	0.6
Acute infarction	9.8	. . .	8.9	11.5	9.3	23.5	0.07
Myocarditis	3.5	5.7	4	3.7	. . .	5.9	0.4
Restrictive CMP	1.7	8.6	2.8	. . .	. . .	. . .	0.002
Reoperation	4.2	14.3	3.6	3.2	4	5.9	0.04
Comorbidities							
Diabetes	26.4	22	19	27	27	37	NS
Hypertension	37.8	32	27	40	45	45	NS
Dyslipidemia	28.4	21	19	28	37	37	NS
Previous transient neurologic event	3.8	5	3	2	2	7	NS
Laboratory values							
Creatinine (mg/dL)	1.6 ± 0.8	1.4 ± 0.5	1.7 ± 0.8	1.6 ± 0.8	1.6 ± 0.8	1.7 ± 0.9	NS
Total bilirubin (mg/dL)	1.6 ± 1.0	1.6 ± 0.5	1.5 ± 0.9	1.5 ± 0.8	1.6 ± 0.9	1.7 ± 1.5	NS
Prothrombin time (s)	15.9 ± 3.1	15.9 ± 3.2	15.6 ± 3.2	15.2 ± 4.5	15.2 ± 3.5	16.1 ± 2.3	NS

BMI = body mass index; CMP = cardiomyopathy; NS = not significant; SD = standard deviation; SEM = standard error of the mean.

24 kg/m²; BMI 25 to 29 kg/m²; BMI 30 to 35 kg/m²; and BMI greater than 35 kg/m². These groups were compared for success rate and morbidity after VAD implantation.

Consent to the study was obtained from all patients.

Outcomes and Definitions

A biventricular assist device (BVAD) or total artificial heart was adopted in the case of multiorgan failure, high central venous pressure, high pulmonary vascular resistance, low mean pulmonary artery pressure, low right ventricular ejection fraction with tricuspid insufficiency, or severe ventricular arrhythmias.

The primary study end points were recovery, transplantation, and 30-day survival, which defined the procedural success after VAD placement. Survival was also assessed as the proportion of patients within each BMI quintiles alive at 180 and 365 days after implantation. Cause of death was studied by dividing deaths into the following complication categories: neurologic, infectious, and multiorgan failure. Change of device, correlated to thrombotic events, was also assessed and analyzed as a postoperative morbidity factor. All the complications were compared among the five groups.

Neurologic complications included transient ischemic attack and embolic or hemorrhagic stroke, considering the special significance of thromboembolism and anticoagulation issues among patients undergoing VAD placement. Infection complications were defined as any positive blood or tissue culture requiring antibiotic therapy. We also specifically studied pump pocket or driveline infections and systemic sepsis. Bleeding complications were defined as requiring more than 5 units of packed red blood cell transfusions within a 24-hour period and requiring rethoracotomy in the operating room.

Statistical Analysis

A univariate analysis was performed to assess associations between patient characteristics and the various patient

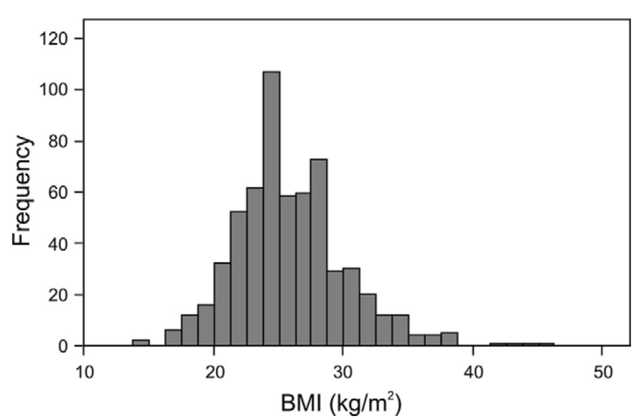

Fig 1. Distribution of body mass index (BMI) in the study population.

Table 2. Types of Assist Devices Implanted in Different Body Mass Index Groups

		BMI				
Device	Overall (n = 590) (%)	<20 kg/m² (n = 35) (%)	20–24 kg/m² (n = 247) (%)	25–29 kg/m² (n = 220) (%)	30–34 kg/m² (n = 72) (%)	>35 kg/m² (n = 16) (%)
BerlinHeart Excor	46.5	48.6	47.2	44.7	46.7	52.9
Incor LVAD	17.7	8.6	15.3	18.4	28	17.6
Novacor LVAD	11.8	14.3	14.1	12.4	4	...
Abiomed BVS 5000	6.6	2.9	6.9	5.5	8	17.6
MicroMed DeBakey LVAD	6.1	14.3	6.9	5.1	4	...
Impella Recover	4.1	5.7	2.8	5.5	2.7	5.9
Cardiowest TAH	2	2.9	2	1.8	2.7	...
LionHeart LVAD	1	...	1.2	0.9	1.3	...
HeartMate I LVAD	1	...	2	0.5	...	...
DuraHeart LVAD	1	2.9	0.4	1.8	...	...
HeartMate II LVAD	0.2	...	...	0.5	...	...
CorAide LVAD	0.2	...	...	0.5	...	...

BMI = body mass index; LVAD = left ventricular assist device; TAH = total artificial heart.

groups based on BMI using χ^2 tests for categorical variables and analysis of variance for continuous variables.

Complications after VAD implantation were compared among the five groups using the same analytic approach. The Kaplan–Meier survival curve was used to assess overall survival. Log-rank statistics were performed to assess statistical significance between survival differences among the five groups. Cox regression analyses were performed to calculate odds ratios (OR) and 95% confidence intervals (CI). The following characteristics were studied as potential predictors: age, sex, dilative cardiomyopathy as primary diagnosis, BVAD implantation, or emergency regimen of VAD placement. A probability value of 0.05 was used to designate statistical significance. Categorical variables are presented as proportions and continuous variables, as means ± standard deviation. All analyses were performed using SPSS for Windows Release 11.5 (SPSS Inc, Chicago, IL).

Results

Patient Characteristics

The average age of the study population was 51.6 ± 12.3 years (range, 18 to 78 years). More than 85.9% of the patients were males. Patient characteristics are shown in Table 1. In our study 5.9% of patients in our study were cachectic, 35.9% overweight, and 14.9% obese. The average BMI was 25.8 ± 4.2 kg/m² with a range from 14.6 kg/m² to 43.8 kg/m² (Fig 1). The average weight and body surface area for the study population were 79.5 ± 14.9 kg (range, 42 to 140 kg) and 1.95 ± 0.017 m² (range, 0.93 to 3.53 m²), respectively (Table 1). Table 2 shows the different types of VAD implanted.

Complications After Ventricular Assist Device

None of the complications differed significantly among the five groups (Table 3). As shown in Table 4 there were no significant differences among BMI groups in unad-

Table 3. Postoperative Assist Device Implantation Complication Rates in Different Body Mass Index Groups

		BMI					
Characteristics	Overall (n = 590) (%)	<20 kg/m² (n = 35) (%)	20–24 kg/m² (n = 247) (%)	25–29 kg/m² (n = 220) (%)	30–34 kg/m² (n = 72) (%)	>35 kg/m² (n = 16) (%)	*p* Value
Infections							
Pump pocket/drive line	2.9	...	2.5	3.7	4.1	...	0.6
Systemic	17.9	8.6	22.2	16.6	13.3	11.8	0.1
Neurologic							
TIA	8.7	2.9	8.3	10.2	9.5	5.9	0.6
Stroke	12.2	11.4	12.9	11.1	14.7	5.9	0.8
Reoperation for bleeding	13.2	20	14.9	11.1	10.8	11.8	0.5
Pump change for thrombosis	11	8.6	10.7	10.6	13.5	11.8	0.9

BMI = body mass index; TIA = transitory ischemic attack.

Table 4. Relationship Between Risk for Complications After Assist Device Implantation in Different Body Mass Index Calculated in Relation to the Body Mass Index Group With Lowest Incidence (BMI = 25–29 kg/m²)[a]

	Unadjusted			Adjusted p Value				
Characteristics	OR	95% CI	p Value	Sex	Age	Emergency	BVAD	DCMP
Wound infection				0.6	0.07	0.5	0.7	0.09
<20 kg/m²	0.0	0.4–5.1	0.9					
20–24 kg/m²	0.6	0.2–1.9	0.4					
30–34 kg/m²	1.2	0.3–4.9	0.7					
>35 kg/m²	0.0	0.4–5.1	0.9					
TIA				0.2	0.2	0.04	0.1	0.6
<20 kg/m²	1.2	0.3–3.8	0.7					
20–24 kg/m²	1.1	0.6–2.1	0.5					
30–34 kg/m²	1.4	0.6–3.1	0.3					
>35 kg/m²	0.5	0.07–4.5	0.5					
Bleeding				0.06	0.4	0.1	0.04	0.1
<20 kg/m²	1.7	0.6–4.6	0.2					
20–24 kg/m²	1.3	0.7–2.3	0.2					
30–34 kg/m²	0.9	0.4–2.2	0.9					
>35 kg/m²	1.1	0.2–5.2	0.9					
Pump change				0.8	0.08	0.7	0.007	0.7
<20 kg/m²	0.6	0.1–2.3	0.5					
20–24 kg/m²	0.9	0.4–1.6	0.7					
30–34 kg/m²	1.2	0.5–2.8	0.5					
>35 kg/m²	0.9	0.2–4.8	0.9					

[a] Odds ratios (OR) and 95% confidence intervals (CI) unadjusted and adjusted are presented.

BMI = body mass index; BVAD = biventricular assist device; DCMP = dilative cardiomyopathy; TIA = transitory ischemic attack.

justed values for wound infection, transient ischemic attacks, bleeding, or incidence of pump change. However, patients of BMI 30 to 34 kg/m² had an elevated risk of pump device change for clotting (OR, 1.2; 95% CI, 0.5 to 2.8), and after adjustment the rate of BVAD implantation was significant ($p = 0.007$).

The same BMI category (30 to 34 kg/m²) had an elevated risk of wound infection (OR, 1.2; 95% CI, 0.3 to 4.9). There was no significance after adjustment.

Patients with BMI less than 20 and 30 to 34 kg/m² had an elevated risk of transient ischemic attack (OR, 1.2; 95% CI, 0.3 to 3.8 and OR, 1.4; 95% CI, 0.6 to 3.1), and after adjustment the frequency of emergency VAD placement was significant ($p = 0.04$).

Patients with BMI less than 20 and 20 to 24 kg/m² showed an elevated risk of rethoracotomy for bleeding (OR, 1.7; 95% CI, 0.6 to 4.6 and OR, 1.3; 95% CI, 0.7 to 2.3), and after adjustment the BVAD placement rate was significant ($p = 004$).

Both stroke and sepsis were causes of death and are discussed below.

Procedural Success and Survival

Overall 232 of 590 (39.3%) patients died on VAD support within 30 days, 116 (19.6%) received heart transplantation, and 47 (7.9%) gained recovery from VAD support. Permanent support was achieved in 12.4% of patients. No statistically significant difference in the distribution for groups was present in all described results. The success rate with odds ratios and ranges, unadjusted and adjusted, in the five groups is summarized in Figure 2. Patients with BMI less than 20 and greater than 35 kg/m² had an elevated risk of postoperative mortality and failure of procedural success (OR, 2.1; 95% CI, 0.9 to 4.7, $p = 0.05$, and OR, 5.8; 95% CI, 1.8 to 18.8, $p = 0.003$, respectively), and after adjustment, greater age ($p = 0.003$), dilative cardiomyopathy as primary diagnosis ($p = 0.000$), and BVAD implantation ($p = 0.001$) were significant.

The 30-, 180-, and 365-day survival after VAD implantation were not significantly different (57.7%, 60%, 65.5%, 59.2%, and 35.3% for 30-day survival; 41.9%, 47.4%, 54.3%, 43.1%, and 23.5% for 180-day survival; 36.5%, 42%, 51.4%, 37.8%, and 23.5% for 365-day survival). Figure 3 demonstrates the Kaplan–Meier survival curves for BMI category and overall VAD patient survival to be without any significant difference.

There was no significant difference for the BMI groups in the rates of cause of death (Table 5).

As shown in Table 6, patients with BMI less than 20 and greater than 35 kg/m² had an elevated risk of multiple organ failure (OR, 2.1; 95% CI, 0.9 to 5.1, $p = 0.05$, and OR, 1.9; 95% CI, 0.5 to 6.2, $p = 0.2$, respectively), and after adjustment, male sex ($p = 0.05$), greater age ($p = 0.05$), dilative cardiomyopathy ($p = 0.02$), BVAD implantation ($p = 0.05$), and emergency VAD placement ($p = 0.01$) were significant.

Patients with BMI 20 to 24 kg/m² had an elevated risk of sepsis as cause of death (OR, 1.3; 95% CI, 0.8 to 2.2). There was no significance after adjustment.

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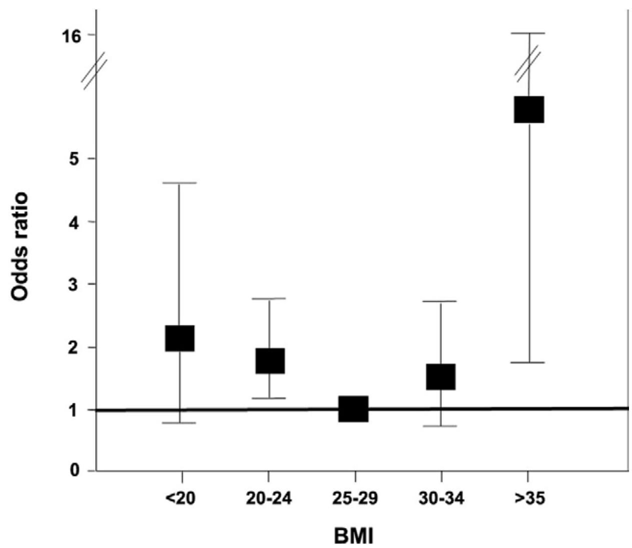


	Unadjusted			Adjusted				
				Gender	Age	Emergency	BVAD	DCMP
BMI	OR	95% CI	p	p	p	p	p	p
				0.9	0.003	0.06	0.001	0.000
<20 kg/m²	2.1	0.9-4.7	0.05					
20-24 kg/m²	1.8	1.1-2.7	0.006					
30-34 kg/m²	1.5	0.8-2.7	0.1					
>35 kg/m²	5.8	1.8-18.8	0.003					

Fig 2. Relationship between risk for 30-day mortality in different body mass index (BMI) groups calculated in relation to the BMI group with lowest incidence (BMI = 25–29 kg/m²). Vertical bars show 95% confidence intervals (CI). Odds ratios (OR) unadjusted and adjusted are given below the figure. (BVAD = biventricular assist device; DCMP = dilative cardiomyopathy.)

Patients with BMI 30 to 34 kg/m² had an elevated risk of stroke as cause of death (OR, 1.16; 95% CI, 0.3 to 4.0), and after adjustment, emergency VAD placement (p = 0.04) was significant.

Comment

In this study, patients with BMI 25 to 29 kg/m² (overweight patients) had the best outcome in terms of procedural success rate. Patients with BMI less than 20 and greater than 35 kg/m² (underweight and morbidly obese, respectively) had an elevated risk of procedural failure. Greater age, cardiomyopathy as primary diagnosis, and BVAD implantation were significant after adjustment. Patients with BMI greater than 35 kg/m² fared significantly worse in the outcome.

There was no significant difference among the five groups in term of mid-term and long-term survival (Fig 3). Neither cause of death nor comorbidities showed a significant difference, in terms of rate and risk, in the different BMI groups. Only cachectic patients (BMI < 20 kg/m²) were at high risk of multiple organ failure as a cause of death. Male sex, advanced age, dilative cardiomyopathy, BVAD, and emergency VAD placement were significantly associated with the result.

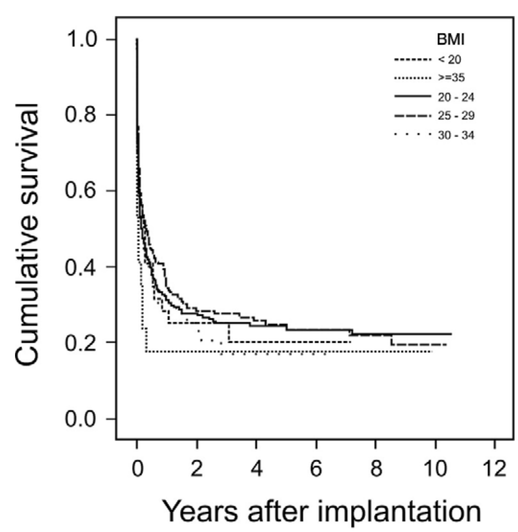
At present, mechanical circulatory support is an expensive option with important risks. Ventricular assist device use should be proposed to patients who can reasonably benefit, in terms of length and quality of life, at a cost comparable to that of other therapies. Consequently, appropriate candidate selection for VAD implantation is necessary. In this context our study addressed the role of nutritional status in VAD outcomes to try to develop clinical criteria for selection.

The BMI expresses nutritional status, as well as metabolic abnormalities and general organ function of patients. We hypothesized that more precise division of patients with regard to BMI would identify patients with optimal BMI and BMI at risk for adverse outcomes and mortality after VAD placement.

Low body mass, as in cachectic patients, is a risk factor in cardiac surgery [3, 4, 6, 10, 11] and in univariate analysis of the Cardiac Transplant Research Database Group [1]. It was previously shown that patients with low BMI are at higher risk after cardiac surgery than obese patients [12]. In another study it was demonstrated that survival after implantation of a VAD is related to body mass at the time of implantation and that survival is poorer in patients with low BMI [9].

Obesity is an independent risk factor for death caused by coronary artery disease [5]. Other work has suggested that overweight subjects, and those at the extremes of the weight range, have a worse prognosis after transplantation [1, 6].

The National Institutes of Health and the World Health Organization define overweight as a BMI of 25 kg/m² or greater and obesity as a BMI of 30 kg/m² or greater [10].



Survival	Overall n=590 %	<20 kg/m² n=35 %	20-24 kg/m² n=247 %	BMI 25-29 kg/m² n=220 %	30-34 kg/m² n=72 %	>35 kg/m² n=16 %	p
30 dd survival mean ± SD	60.7±2.0	57.7±5.8	60±8.2	65.5±3.3	59.2±3.2	35.3±12.1	ns
1 y survival mean ± SD	39.6±1.9	36.5±7.9	42±3.1	51.4±3.4	37.8±5.7	23.5±10.8	ns
5 yy survival mean ± SD	23.2±1.9	20.2±7.6	22.8±3.0	24.2±3.3	25±10.8	17±0.5	ns

Fig 3. Kaplan–Meier curves of survival stratified by body mass index (BMI) in the years after implantation (log-rank test). (SD = standard deviation.)

Table 5. Causes of Death After Assist Device Implantation in Different Body Mass Index Groups

Characteristics	Overall (n = 590) (%)	BMI <20 kg/m² (n = 35) (%)	20–24 kg/m² (n = 247) (%)	25–29 kg/m² (n = 220) (%)	30–34 kg/m² (n = 72) (%)	>35 kg/m² (n = 16) (%)	p Value
Multiple organ failure	20.1	28.6	20.6	16.6	22.7	29.4	0.3
Infectious	17.9	8.6	22.2	16.6	13.3	11.8	0.1
Neurologic	12.2	11.4	12.9	11.1	14.7	5.9	0.8

BMI = body mass index.

Although Roques and colleagues [11] classified patients with a BMI of 33 kg/m^2 or greater as morbidly obese, Birkmeyer and associates [12], on the other hand, defined patients with a BMI of 36 kg/m^2 or greater as severely obese.

According to these proposals, we divided our population into five BMI groups, thus defining two classes for obesity (30 to 34 and greater than 35 kg/m^2), with a small number of patients (n = 16) in the last class.

This study shows that heart failure patients with very low body weight can undergo VAD placement successfully and that the presence of cardiac cachexia and severe protein-calorie depletion, as one manifestation of far advanced heart failure, need not be an exclusion criterion for such treatment. The results suggest that underweight patients, because of the underlying extremely poor prognosis [13, 14], have, owing to the restoration of normal hemodynamics, a greater benefit from VAD placement compared with patients with higher body weight.

These results are similar to those of Deng and coworkers [15] and Clark and associates [16], who have suggested that the survival benefit from heart transplantation is greatest in patients with the poorest prognosis as assessed by a validated score [17].

Two-year use of an LVAD prolongs survival in patients with end-stage heart failure [2]. Both transplantation and LVAD implantation are major surgical interventions that substantially improve cardiac output. One important difference between the two is the use of immune modulatory therapy after transplantation. We hypothesize that implantation of VAD support earlier and with less invasive methods together with several other interventions, including intensified nutrition and hormonal treatment, could be even more successful in this category of patients.

Meanwhile, the better nutritional, immunologic, metabolic, and inflammatory profile probably allows normal and even overweight end-stage heart failure patients to tolerate the perioperative stressors of VAD placement well. In chronic heart failure, being overweight is not associated with adverse prognosis [18].

Severe and morbidly obese patients with high cholesterol and possibly several comorbidities that reduce their

Table 6. Relationship Between Risk for Cause of Death After Assist Device Implantation in Different Body Mass Index Calculated in Relation to the Body Mass Index Group With Lowest Incidence (BMI = 25–29 kg/m²)[a]

Characteristics	Unadjusted OR	Unadjusted 95% CI	Unadjusted p Value	Adjusted p Value: Sex	Age	Emergency	BVAD	DCMP
Multiple organ failure				0.05	0.01	0.01	0.05	0.02
<20 kg/m²	2.1	0.9–5.1	0.05					
20–24 kg/m²	1.3	0.8–2.2	0.2					
30–34 kg/m²	1.4	0.7–2.7	0.2					
>35 kg/m²	1.9	0.5–6.2	0.2					
Infectious				0.4	0.1	0.4	0.7	0.3
<20 kg/m²	0.4	0.1–1.6	0.2					
20–24 kg/m²	1.3	0.8–2.2	0.1					
30–34 kg/m²	0.7	0.3–1.6	0.5					
>35 kg/m²	0.7	0.1–3.3	0.6					
Neurologic				0.1	0.3	0.04	0.1	0.4
<20 kg/m²	0.9	0.3–3.03	0.9					
20–24 kg/m²	0.8	0.2–2.5	0.7					
30–34 kg/m²	1.1	0.3–4.04	0.8					
>35 kg/m²	0.4	0.04–4.5	0.5					

[a] Odds ratios (OR) and 95% confidence intervals (CI) unadjusted and adjusted are presented.

BMI = body mass index; BVAD = biventricular assist device; DCMP = dilative cardiomyopathy.

pathophysiologic status remain high-risk patients for VAD placement, as for both routine cardiac surgery and transplantation.

In conclusion, in our opinion, cardiac cachexia need not be an exclusion criterion for VAD placement. Underweight patients appear to experience greater benefit from mechanical support. Severely obese patients should be carefully selected before VAD placement. Early implantation of VAD could restore the hemodynamics and BMI of patients in the low BMI population, thus stabilizing and preparing them for heart transplantation in a shorter time than with pharmacologic therapy only. According to the acceptable outcomes in both low and high BMI VAD patients, the mechanical support approach, as treatment of end-stage heart failure, could provide a therapeutic alternative for cachectic or overweight and obese patients without diverting scarce hearts from lower risk patients. However, further investigations on the issue are clearly necessary.

The present study is a retrospective, secondary analysis of a registry, and not a prospective or randomized study designed to address this specific question. There is a natural bias in the clinical assessment of the patient groups. The most obvious limitation is the small number of patients in the last BMI group, which, however, often represents the smallest cohort in a VAD patient population. We do not have complete data on the pattern of weight change after VAD placement, and further study is clearly needed. Several types of VADs were used in the study population but with no significant difference in their distribution in the groups analyzed. The type of VAD did not significantly affect the outcome in the groups of the population. Body mass index is an indicator of nutritional status, and edema may falsify its estimation. Therefore the collection of more nutritional laboratory variables and their analysis in a further study are clearly necessary.

Despite these limitations, the present study represents an attempt to analyze the influence of BMI on the outcome of VAD candidates in a large population as a single-center experience.

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References

1. Grady KL, White-Williams C, Naftel DC, et al. Are preoperative obesity and cachexia risk factors for post heart transplant morbidity and mortality: a multi-institutional study of preoperative weight-height indices. Cardiac Transplant Research Database (CTRD) Group. J Heart Lung Transplant 1999;18:750–63.
2. Rose EA, Gelijns AC, Moskowitz AJ, et al. Long-term use of a left ventricular assist device for end stage heart failure. N Engl J Med 2001;345:1435–43.
3. Lietz K, John R, Burke EA, et al. Pretransplant cachexia and morbid obesity are predictors of increased mortality after heart transplantation. Transplantation 2001;72:277–83.
4. Engelman DT, Adams DH, Byrne JG, et al. Impact of body mass index and albumin on morbidity and mortality after cardiac surgery. J Thorac Cardiovasc Surg 1999;118:866–73.
5. Pi-Sunyer FX. Medical hazards of obesity. Ann Intern Med 1993;119:655–60.
6. Grady KL, Costanzo MR, Fischer S, Koch D. Preoperative obesity is associated with decreased survival after heart transplantation. J Heart Lung Transplant 1996;15:863–71.
7. Clark AL, Loebe M, Potapov EV, et al. Ventricular assist device in severe heart failure: effects on cytokines, complement and body weight. Eur Heart J 2001;22:2275–83.
8. Butler J, Howser R, Portner PM, Pierson RN. Body mass index and outcomes after left ventricular assist device placement. Ann Thorac Surg 2005;79:66–73.
9. Potapov EV, Loebe M, Anker S, et al. Impact of body mass index on outcome in patients after coronary artery bypass grafting with and without valve surgery. Eur Heart J 2003;24:1933–41.
10. National Institutes of Health. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: the evidence report. Obes Res 1998;6(Suppl 2):51S–209S.
11. Roques F, Nashef SA, Michel P, et al. Risk factors and outcome in European cardiac surgery: analysis of the EuroSCORE multinational database of 19030 patients. Eur J Cardiothorac Surg 1999;15:816–23.
12. Birkmeyer NJ, Charlesworth DC, Hernandez F, et al. Obesity and risk of adverse outcomes associated with coronary artery bypass surgery: Northern New England Cardiovascular Disease Study Group. Circulation 1998;97:1689–94.
13. Anker S, Ponikowski P, Varney S, et al. Wasting as an independent risk factor for mortality in chronic heart failure. Lancet 1997;349:1050–3.
14. Davos CH, Doehner W, Rauchhaus M, et al. Body mass and survival in patients with chronic heart failure without cachexia: the importance of obesity. J Card Fail 2003;9:29–35.
15. Deng MC, De Meester JM, Smits JM, Heinecke J, Scheld HH. Effect of receiving a heart transplant: analysis of a national cohort entered on to a waiting list, stratified by heart failure severity. Comparative Outcome and Clinical Profiles in Transplantation (COCPIT) Study Group. BMJ 2000;321:540–5.
16. Clark AL, Knosalla C, Birks E, et al. Heart transplantation in heart failure: the prognostic importance of body mass index at time of surgery and subsequent weight changes. Eur J Heart Fail 2007;9:839–44.
17. Aaronson KD, Schwartz JS, Chen TM, Wong KL, Goin JE, Mancini DM. Development and prospective validation of a clinical index to predict survival in ambulatory patients referred for cardiac transplant evaluation. Circulation 1997;95:2660–7.
18. Horwich TB, Fonarow GC, Hamilton MA, MacLellan WR, Woo MA, Tillisch JH. The relationship between obesity and mortality in patients with heart failure. J Am Coll Cardiol 2001;38:789–95.