Journal of Geriatric Cardiology (2018) 15: 261–267


*Research Article* · **Open Access** ·

# Long-term follow-up of quality of life in high-risk patients undergoing transcatheter aortic valve implantation for symptomatic aortic valve stenosis

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**Abstract**

**Background** Transcatheter aortic valve implantation (TAVI) has become the standard treatment for patients with severe symptomatic aortic stenosis (AS) considered at very high risk for surgical aortic valve replacement. The purpose of this sub-study was to evaluate long-term (> 4 years) health-related quality of life (QoL) in octogenarians who underwent TAVI. **Methods** A single center observational registry in twenty patients who underwent frame analysis assessment ≥ 4 years after TAVI. Health-related QoL was evaluated, using the Short Form-36 (SF-36), the EuroQoL-5D (EQ-5D) and the visual analogue score (EQ-VAS) questionnaires. **Results** The mean SF-36 sub-scale scores at follow-up were physical functioning 40.8 ± 26.3, role physical functioning 67.7 ± 34.9, vitality 54.6 ± 21.6, general health 52.1 ± 20.4, social functioning 63.8 ± 37.7, role emotional functioning 70.2 ± 36.0, mental health 73.2 ± 23.3 and bodily pain 80.9 ± 22.9. The mean EQ-VAS score > 4 years after TAVI was 64.7 ± 15.1. With respect to functional class, 80% of the patients were in NYHA class I/II at follow-up compared to 15% prior to TAVI. **Conclusions** This sub-study reports a significant improvement in functional class (NYHA) in a selected group of very elderly patients > 4 years after TAVI. Furthermore, all patients showed a satisfactory QoL despite their age and multiple comorbidities. In addition, our study reveals a lower QoL when compared with the general age matched Dutch population.

*J Geriatr Cardiol* 2018; 15: 261–267. doi:10.11909/j.issn.1671-5411.2018.04.003

**Keywords:** Octogenarians; Quality of life; Transcatheter aortic valve implantation

## 1 Introduction

Degenerative aortic valve stenosis is a very common valvular heart disorder in adults aged > 65 years in industrialized countries, with a prevalence rate of 3%–9%.[1,2] Surgical aortic valve replacement (SAVR) has been the standard of care for these patients. However, at least one third of the patients are considered too high at risk or inoperable for SAVR due to multiple comorbidities. In the last decade, transcatheter aortic valve implantation (TAVI) has emerged as a less-invasive treatment for these patients with > 300,000 procedures performed to date. Importantly, its use is still growing,[3–6] as the field of TAVI is rapidly evolving due to improvements in catheter and valve technology, procedural techniques and refined patient selection. Consequently, knowledge of long-term structural device integrity and patient-reported outcomes are important to guide this development.[7,8]

Most patients undergoing TAVI are octogenarians with multiple co-morbidities and reduced health related quality of life (QoL).[9] In these patients, the importance of QoL may be as or even more important than survival.[10,11] Moreover, meaningful long-term benefit of QoL post-TAVI is of importance to guide patient-centered decision-making as well as identifying predictors for improvement of QoL post-TAVI. Yet, information on true long-term results is lacking.

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**Received:** February 22, 2018 **Revised:** April 11, 2018
**Accepted:** April 16, 2018 **Published online:** April 23, 2018

Accordingly, we initiated study on the long-term integrity of the self-expanding Medtronic CoreValve System (Medtronic Inc. Minneapolis MN) to analyse QoL and functional health status at a minimum of 4 years after TAVI.[12]

The main objective of this sub-study is to investigate long-term health related quality of life and functional health status. A sub-analysis was performed to compare QoL of participants with the general age matched Dutch population.

## 2 Methods

Between November 2005 and March 2012, a total of 259 patients with severe symptomatic aortic valve stenosis received a TAVI in the Erasmus Medical Centre, Rotterdam. After checking survival status in January 2016 at the Municipal Civil Registry, survivors were evaluated for assessment of long-term valve function (transthoracic echocardiography) and frame integrity of the self-expanding CoreValve (Multi Slice Computed Tomography—TACT study).[12]

Only patients who underwent TAVI > 4 years earlier were eligible. Given the nature of the study that included MSCT, patients with renal failure, known hypersensitivity or contraindication to intravenous contrast in addition to patients with previous stroke, a language barrier and treatment with a valve other than the self-expanding CoreValve were not included in the present study. Patients who fulfilled these study-criteria were contacted for both long-term valve & frame analysis and health-related status. The Medical Ethics Committee approved the study (MEC-2013-331) and all participants signed the informed consent. After written informed consent, patients were scheduled for a one-day out-patient visit during which data on valve function, health status and QoL were collected. A sub-analysis was performed to compare the measured health related QoL at follow-up in TACT patients with the general Dutch population as stratified by age > 70 years. No data on baseline QoL was available.

### 2.1 Baseline characteristics

Socio-demographic characteristics included gender and age. Cardiovascular risk factors included: diabetes mellitus, hypertension, pulmonary vascular disease, previous stroke, atrial fibrillation, previous pacemaker, chronic obstructive pulmonary disease, pulmonary hypertension and chronic kidney disease. Clinical characteristics included: history of coronary artery disease, peak aortic valve velocity, left ventricular ejection fraction, NYHA classification and Log EuroSCORE (European System for Cardiac Operative Risk Evaluation). All data on baseline and the medical history of patients were collected from the medical records.

### 2.2 Health status

Health-related QoL was measured with the generic Short Form 36 Health Survey (SF-36) and the EuroQoL-5-dimensions-5 levels (EQ-5D-5L) questionnaires. The SF-36 questionnaire is a validated and widely accepted instrument to measure overall physical and mental health status. It consists of 36 items, which measures eight health-related dimensions covering physical functioning, role physical, bodily pain, general health, role emotional, social functioning, vitality and mental health. Each item is scored in a 0–100 range, with higher scores reflecting a better QoL.[13]

The EQ-5D-5L is a generic health utility QoL instrument and is qualified for measuring health status within an elderly population (EuroQoL Group, Rotterdam, The Netherlands).[14] This descriptive system consists of five domains (i.e., mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) each of which is divided in five levels of functioning [i.e., no problems (level 1), some or moderate problems (level 2 and 3), and severe or extreme problems (level 4 and 5)]. Theoretically, 3125 different health status can be generated by this classification, which can be converted to a utility score, ranging from –0.446 to 1 (a value of 1 indicating full health, while a value lower than 0 represents a status considered to be worse than death). The second part of the EQ-5D includes a visual analog scale (EQ-VAS), ranging from 0 ("Worst imaginable health state") to 100 ("Best imaginable health state").[15] Both SF-36 and EQ-5D, questionnaires were administered and collected during in-person visits > 4 years after TAVI.

### 2.3 Statistical analysis

Continuous variables are expressed as mean ± SD. Dichotomous variables are presented as numbers and percentages. To evaluate differences between TACT participants and surviving non-participants chi-square tests, students *t*-test or Mann-Whitney tests were applied as appropriate. $P < 0.05$ was considered statistically significant. All analyses were performed using SPSS version 21 for Windows (SPSS Inc, Chicago, IL).

## 3 Results

### 3.1 Patient characteristics

Of the 259 patients who underwent TAVI between 2005 and 2012, 158 (61%) patients died before the time of inclusion (January 2016) with a mean survival time for the total cohort of 4.7 years (95% CI: 4.16–5.14). Out of the

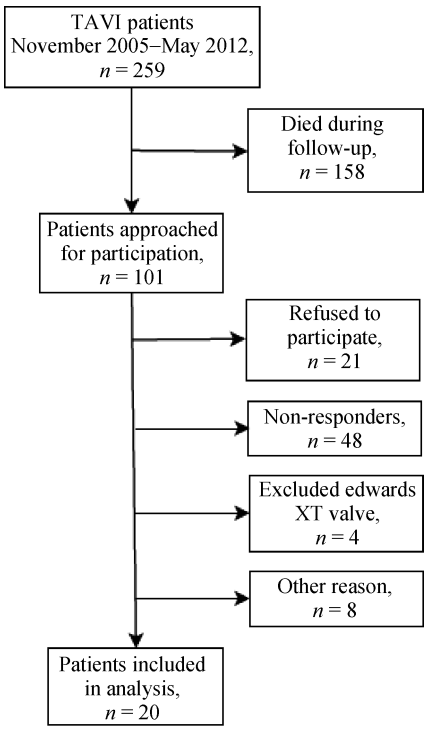


**Figure 1. Study flowchart of number of total TAVI patients between 2005 and 2012, non-responders (*n* = 81) and the final study population with more than 4 years follow-up data post-TAVI (*n* = 20).** TAVI: transcatheter aortic valve implantation.

101 remaining patients, 81 patients did not participate in the TACT study due to exclusion criteria or non-response. Other reasons were the lack of social support or due to physical or mental disabilities. The remaining 20 patients with a mean follow-up period of 5.5 years (range 4–10 years) provided written informed consent and were included in the current analysis (Figure 1).

Baseline data of all 101 patients are shown in Table 1, including a comparison between participants (*n* = 20) in the TACT sub-study and surviving non-participants (*n* = 81). Most patients suffered from multiple comorbidities and high surgical risk (mean logistic EuroSCORE 15.4% ± 9.8%). The mean age at the time of TAVI was 80 ± 8.0 years, and almost half were men. The majority of participants (77%) had a poor functional status (NYHA III/IV) before TAVI. Overall, there were no significant differences on baseline characteristics between participants and surviving non-participants, except for left ventricular ejection fraction (LVEF).

### 3.2 (Post-) Procedural outcomes

On post-procedural outcomes no differences between participants and non-participants were found. As shown in Table 2, all participants underwent successful TAVI with femoral access, general anesthesia as standard of care at

**Table 1. Baseline patient characteristics.**

| | Total population (*n* = 101) | Non-participants (*n* = 81) | Participants (*n* = 20) | *P*-value |
|---|---|---|---|---|
| Mean age, yrs | 79.7 ± 8.0 | 80.2 ± 8.0 | 77.9 ± 7.7 | 0.26 |
| Male sex | 49 (49%) | 38 (47%) | 11 (55%) | 0.52 |
| Body mass index, kg/m$^2$ | 26.8 ± 3.9 | 26.5 ± 3.4 | 27.9 ± 5.3 | 0.16 |
| Cardiovascular risk factors | | | | |
| Diabetes mellitus | 21 (21%) | 18 (22%) | 3 (15%) | 0.48 |
| Hypertension | 60 (59%) | 47 (58%) | 13 (65%) | 0.57 |
| PVD | 8 (8%) | 7 (9%) | 1 (5%) | 0.59 |
| Previous stroke | 20 (20%) | 15 (19%) | 5 (25%) | 0.52 |
| Atrial fibrillation | 22 (22%) | 17 (21%) | 5 (25%) | 0.70 |
| Previous pacemaker | 12 (12%) | 9 (11%) | 3 (15%) | 0.63 |
| COPD | 21 (21%) | 15 (19%) | 6 (30%) | 0.26 |
| PHT | 7 (7%) | 5 (6%) | 2 (10%) | 0.55 |
| Chronic kidney disease | 16 (16%) | 12 (15%) | 4 (20%) | 0.57 |
| History of CAD | 50 (50%) | 38 (47%) | 12 (60%) | 0.30 |
| Peak AoV, m/s | 4.3 ± 0.8 | 4.3 ± 0.8 | 4.3 ± 0.9 | 0.75 |
| LVEF | 51.7% ± 14.1% | 53.7% ± 12.7% | 44.4% ± 17.0% | 0.01 |
| NYHA classification | | | | 0.30 |
| I / II | 23 (23%) | 20 (25%) | 3 (15%) | |
| III / IV | 78 (77%) | 61 (75%) | 17 (85%) | |
| Logistic EuroSCORE | 15.4% ± 9.8% | 14.5% ± 9.5% | 18.9% ± 10.8% | 0.07 |

Data are presented as mean ± SD or *n* (%) unless other indicated. AoV: Aortic valve velocity; CAD: coronary artery disease; COPD: chronic obstructive pulmonary disease; EuroSCORE: European System for Cardiac Operative Risk Evaluation; LVEF: left ventricular ejection fraction; NYHA: New York Heart Association; PHT: pulmonary hypertension; PVD: pulmonary vascular disease.

**Table 2. Procedural and post-procedural outcomes.**

| | Total population (*n* = 101) | Non-participants (*n* = 81) | TACT-participants (*n* = 20) | *P*-value |
|---|---|---|---|---|
| **Procedural outcomes** | | | | |
| Access trans femoral | 100 (99%) | 80 (99%) | 20 (100%) | 0.62 |
| Pre-dilatation | 97 (98%) | 78 (98%) | 19 (95%) | 0.49 |
| MCV | 97 (96%) | 77 (95%) | 20 (100%) | 0.31 |
| Device success | 98 (97%) | 78 (98%) | 20 (100%) | 0.38 |
| Post-dilatation | 14 (14%) | 9 (11%) | 5 (25%) | 0.11 |
| Total contrast, cc | 135 ± 68.5 | 132.9 ± 69.1 | 146.3 ± 66.7 | 0.47 |
| Procedure time | 193 ± 65.0 | 190.9 ± 65.3 | 203.4 ± 64.7 | 0.47 |
| **Post-procedural outcomes** | | | | |
| Aortic valve regurgitation | | | | 0.58 |
| Mild | 27 (27%) | 22 (28%) | 5 (25%) | |
| Moderate/severe | 6 (6%) | 4 (5%) | 2 (10%) | |
| Permanent pacemaker | 15 (15%) | 11 (14%) | 4 (20%) | 0.47 |
| Bleeding more than 1 day | | | | 0.85 |
| Minor | 9 (9%) | 7 (9%) | 2 (10%) | |
| Major | 11 (11%) | 9 (11%) | 2 (10%) | |
| Life threatening | 6 (6%) | 4 (5%) | 2 (10%) | |
| Major vascular complication | 6 (6%) | 5 (6%) | 1 (5%) | 0.58 |
| Place of discharge | | | | 0.61 |
| Home | 91 (90%) | 71 (88%) | 20 (100%) | |
| Other location | 10 (10%) | 10 (12%) | 0 (0%) | |
| Length of stay, days | 9.2 ± 5.1 | 9.0 ± 4.3 | 10.4 ± 7.6 | 0.28 |

Data are presented as mean ± SD or *n* (%) unless other indicated. MCV: Medtronic CoreValve.

that time, a mean procedure time of 203 ± 64.7 min and a mean hospitalization time of 10.4 ± 7.6 days. Post-procedural complications included one participant with a major vascular complication and four participants who required a permanent pacemaker. Major bleeding after more than one day occurred in six participants of which two were life threatening.

### 3.3 Health status

The SF-36, EQ-5D-5L and EQ-VAS scores are shown in Table 3. The mean SF-36 subscale scores at follow-up were physical functioning 40.8 ± 26.3, role physical functioning 67.7 ± 34.9, vitality 54.6 ± 21.6, general health 52.1 ± 20.4, social functioning 63.8 ± 37.7, role emotional functioning 70.2 ± 36.0, mental health 73.2 ± 23.3 and bodily pain 80.9 ± 22.9. With attention to EQ-5D, mobility was found to be the most frequent reported limitation (75%) while self-care was the least frequent reported limitation (35%). The majority of the participants had moderate limitations in all subdomains. The mean utility index and EQ-VAS score were 0.69 ± 0.29 and 64.7 ± 15.1. Table 3 also shows a comparison of the QoL in TACT participants with the mean QoL values of the age adjusted Dutch population. With respect to functional class expressed by NYHA, 80% had mild symptoms (class I or II) at follow-up versus 15% before TAVI, indicating a significant functional improvement (Table 1 and 3).

## 4 Discussion

The main findings of the present study in a selected group of octogenarians who underwent TAVI > 4 years ago because of severe AS are a significant improvement in functional class (NYHA) and a satisfactory QoL.

Although we recognize that the herein included patients represent a selected group of TAVI patients, this study confirms the improvements reported in other studies but over a longer period of time.[16–18] Indeed, previous studies mainly focus on the first post-procedural period (up to one year) while in this study the mean follow-up time was 5.5 years. The improvement in functional class and the findings in health related outcome is noteworthy given the age and comorbid conditions in these patients. In line with others, sustainable improvement of NYHA class has been observed in long-term survivors, as NYHA class I/II has been observed in most patients, who were in NYHA III/IV prior to TAVI.[19,20] This indicates that these patients, despite multiple comorbid conditions and advanced age, clearly benefit from this invasive procedure.

**Table 3. Quality of Life Scores at follow-up (6 years) in TACT-participants.**

| | TACT-subgroup (*n* = 20) | Dutch population* |
|---|---|---|
| SF-36 | | |
| Physical functioning | 40.8 ± 26.3 | 58.9 ± 30.8 |
| Role physical functioning | 67.7 ± 34.9 | 56.9 ± 44.0 |
| Vitality | 54.6 ± 21.6 | 61.8 ± 23.6 |
| General health | 52.1 ± 20.4 | 58.9 ± 21.1 |
| Social functioning | 63.8 ± 37.7 | 75.6 ± 27.0 |
| Role emotional functioning | 70.2 ± 36.0 | 74.5 ± 38.2 |
| Mental health | 73.2 ± 23.3 | 73.0 ± 19.9 |
| Bodily pain | 80.9 ± 22.9 | 68.1 ± 27.4 |
| EQ-5D (% of patients indicating a problem) | | |
| Mobility | 75.0% | 36.5% |
| Self-care | 35.0% | 11.7% |
| Usual activities | 65.0% | 26.0% |
| Pain/discomfort | 60.0% | 48.5% |
| Anxiety/depression | 40.0% | 3.6% |
| Utility score | 0.69 ± 0.29 | 0.85 ± 0.15 |
| VAS | 64.7 ± 15.1 | 72.9 ± 24.3 |
| NYHA classification | | |
| I/II | 16 (80%) | |
| III/IV | 4 (20%) | |

Data are presented as mean ± SD or *n* (%) unless other indicated. *Dutch population norms for the SF-36 are stratified by age > 70 years;[29] Dutch population norms for the EQ-5D are stratified by age > 75 years.[15] EQ-5D: EuroQoL 5 Dimensions; SF-36: Short Form (36) Health Survey; VAS: Visual Analogue Score.

With respect to health-related QoL, the majority of the participants showed satisfactory QoL scores > 4 years after TAVI. In addition, our study reveals a lower QoL when compared with the general age adjusted Dutch population.[15] Ware, *et al*.[21] described that a 5-point difference between groups or a 5-point change over time is considered clinically and socially relevant. Our participants scored lower on most SF-36 subscales and all EQ-5D subdomains when compared to the Dutch population as stratified by age > 70 years.[15,22] The differences in health scores on the physical scales of the SF-36 are more than five points and therefore should be considered clinically and socially relevant. With attention to bodily pain, the participants scored higher on the SF-36 subscale. A possible explanation is that patients are getting used to their physical limitations and multiple comorbidities,[23,24] which could result in a lower sensitivity for pain. These findings indicate that within elderly people, large QoL differences exist and may under scribe the need for more long-term follow-up research, with standardized QoL instruments specific developed for patients with AS.

In comparison, the Partner study was the first to show a substantial improvement of QoL at 1-year follow-up after either TAVI or SAVR in high-risk elderly patients.[25] Baseline EQ-5D utility score increased by 14% to 0.66 at 1-year post-TAVI. Fairbairn, *et al*.[18] had shown that QoL, as measured with the EQ-5D and EQ-VAS, improved early after TAVI and was maintained at 1-year post-TAVI. The German TAVI registry revealed that patients with a low baseline EQ-5D had a significantly better improvement in QoL one year after TAVI.[17]

Other studies also showed a significant improvement at one-year follow-up in all SF-36 domains with higher summary scale scores than the general population-norms.[26,27] Unfortunately, we could not perform an age- and co-morbidity matched comparison precluding firm conclusions or interpretation. Of note, the mean age of the reference data in the general Dutch population is standardized to 70+ whereas the mean age in our population was 79.7 years. It is important to note that an increase in age is associated with a decrease in QoL, indicating a decline in the slope of people's self-rated health over the decades of their life.[15] Mangen, *et al*.[28] reported that impairment increases rapidly with age, but health status is also associated with socio-demographic variables and comorbidities. These findings are consistent with our findings that increasing age and multiple co-morbidities can be associated with lower QoL.

### 4.1 Limitations

Our study is a single-center study and based on a small group of selected patients (20 participants of long-term survivors) most likely representing a group of most vital patients who agreed to participate in a clinical research project. Therefore selection bias may have occurred. Second, our analyses are based on a population including the first TAVI patients in the Netherlands. All procedures were performed under general anesthesia in patients with an extremely high-risk status and therefore might not represent a contemporary TAVI population.

### 4.2 Conclusions

This sub-study in a selected group of very elderly patients who underwent frame analysis assessment ≥ 4 years after TAVI reports significant improvement in functional class (NYHA). Furthermore, all patients showed a satisfactory quality of life despite their age and multiple comorbidities. In addition, our study reveals a lower QoL when compared with the general age matched Dutch population. The

observed improvement in functional status reflects a positive long-term outcome of TAVI in this selected group of octogenarians. These benefits should be taken into account when discussing the indication for elderly patients undergoing TAVI. Further research is warranted on long-term health-related QoL in a high-risk population with aortic stenosis.

## Acknowledgement

The authors declare that there is no conflict of interest.

## References

1 Iung B, Baron G, Butchart EG, *et al*. A prospective survey of patients with valvular heart disease in Europe: The Euro Heart Survey on Valvular Heart Disease. *Eur Heart J* 2003; 24: 1231–1243.
2 Nkomo VT, Gardin JM, Skelton TN, *et al.* Burden of valvular heart diseases: a population-based study. *Lancet* 2006; 368: 1005–1011.
3 Adams DH, Popma JJ, Reardon MJ, *et al*. Transcatheter aortic-valve replacement with a self-expanding prosthesis. *N Engl J Med* 2014; 370: 1790–1798.
4 Thyregod HG, Steinbruchel DA, Ihlemann N, *et al*. Transcatheter versus surgical aortic valve replacement in patients with severe aortic valve stenosis: 1-year results from the All-Comers NOTION Randomized Clinical Trial. *J Am Coll Cardiol* 2015; 65: 2184–2194.
5 Reinohl J, Kaier K, Reinecke H, *et al*. Effect of availability of transcatheter aortic-valve replacement on clinical practice. *N Engl J Med* 2015; 373: 2438–2447.
6 Osnabrugge RLJ, Mylotte D, Head SJ, *et al*. Aortic stenosis in the elderlydisease prevalence and number of candidates for transcatheter aortic valve replacement: a meta-analysis and modeling study. *J Am Coll Cardiol* 2013; 62: 1002–1012.
7 Hamm CW, Arsalan M, Mack MJ. The future of transcatheter aortic valve implantation. *Eur Heart J* 2016; 37: 803–810.
8 Wenaweser P, Stortecky S, Schwander S, *et al*. Clinical outcomes of patients with estimated low or intermediate surgical risk undergoing transcatheter aortic valve implantation. *Eur Heart J* 2013; 34: 1894–1905.
9 Olsen SJ, Fridlund B, Eide LS, *et al*. Changes in self-reported health and quality of life in octogenarian patients one month after transcatheter aortic valve implantation. *Eur J Cardiovasc Nurs* 2017; 16: 79–87.
10 Smith CR, Leon MB, Mack MJ, *et al*. Transcatheter versus surgical aortic-valve replacement in high-risk patients. *N Engl J Med* 2011; 364: 2187–2198.
11 Reynolds MR, Magnuson EA, Wang K, *et al*. Health-related quality of life after transcatheter or surgical aortic valve replacement in high-risk patients with severe aortic stenosis: results from the PARTNER (Placement of AoRTic TraNscathetER Valve) Trial (Cohort A). *J Am Coll Cardiol* 2012; 60: 548–558.
12 El Faquir N, Ren B, Faure M, *et al*. Long-term structural integrity and durability of the medtronic corevalve system after transcatheter aortic valve replacement. *JACC Cardiovasc Imaging*. Published Online First: Nov 10, 2017. DOI: 10.1016/j.jcmg.2017.08.019.
13 Ware JE, Jr., Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care* 1992; 30: 473–483.
14 Purba FD, Hunfeld JA, Iskandarsyah A, *et al*. Employing quality control and feedback to the EQ-5D-5L valuation protocol to improve the quality of data collection. *Qual Life Res* 2017; 26: 1197–1208.
15 Szende A, Janssen B, Cabases J. Self-reported population health: an international perspective based on EQ-5D. Http://download.springer.com/static/pdf/471/bok%253A978–94-007–7596–1.pdf?originUrl=http%3A%2F%2Flink.springer.com%2Fbook%2F10.1007%2F978–94-007–7596–1&token2=exp=1472643840~acl=%2Fstatic%2Fpdf%2F471%2Fbok%2525 3A978-94-007-7596-1.pdf%3ForiginUrl%3Dhttp%253A%252F%252Flink.springer.com%252Fbook%252F10.1007%252F978-94-007-7596-1*~hmac=1f565cbe531e5fe1637b25252b770ddf0abcf4db439f019e0180d1f0cdcc4f7b (accessed February 15, 2018).
16 Makkar RR, Fontana GP, Jilaihawi H, *et al*. Transcatheter aortic-valve replacement for inoperable severe aortic stenosis. *N Engl J Med* 2012; 366: 1696–1704.
17 Biermann J, Horack M, Kahlert P, *et al*. The impact of transcatheter aortic valve implantation on quality of life: results from the German transcatheter aortic valve interventions registry. *Clin Res Cardiol* 2015; 104: 877–886.
18 Fairbairn TA, Meads DM, Mather AN, *et al*. Serial change in health-related quality of life over 1 year after transcatheter aortic valve implantation: predictors of health outcomes. *J Am Coll Cardiol* 2012; 59: 1672–1680.
19 Avanzas P, Pascual I, Munoz-Garcia AJ, *et al*. Long-term follow-up of patients with severe aortic stenosis treated with a self-expanding prosthesis. *Rev Esp Cardiol* (*Engl Ed*) 2017; 70: 247–253.
20 Codner P, Orvin K, Assali A, *et al*. Long-term outcomes for patients with severe symptomatic aortic stenosis treated with transcatheter aortic valve implantation. *Am J Cardiol* 2015; 116: 1391–1398.
21 Ware J. SF-36 Health Survey manual and interpreatation guide. Boston: the health Institute, New England Medical Centre; 1993.
22 Zee Kvd. Het meten van de algemene gezondheidstoestand met de Rand-36. Https://www.umcg.nl/SiteCollectionDocuments/research/institutes/SHARE/assessment%20tools/handleiding_rand36_2e_druk.pdf (accessed February 15, 2018).
23 Green P, Arnold SV, Cohen DJ, *et al*. Relation of frailty to

outcomes after transcatheter aortic valve replacement (from the PARTNER trial). *Am J Cardiol* 2015; 116: 264–269.

24 Orvin K, Dvir D, Weiss A, *et al*. Comprehensive prospective cognitive and physical function assessment in elderly patients undergoing transcatheter aortic valve implantation. *Cardiology* 2014; 127: 227–235.

25 Reynolds MR, Magnuson EA, Wang K, *et al*. Health-related quality of life after transcatheter or surgical aortic valve replacement in high-risk patients with severe aortic stenosis results from the PARTNER (Placement of AoRTic TraNscathetER Valve) Trial (Cohort A). *J Am Coll Cardiol* 2012; 60: 548–558.

26 Georgiadou P, Sbarouni E, Karavolias GK, Voudris V. Transcatheter aortic valve implantation: restoring the qualities of life in old age. *Age Ageing* 2013; 42: 21–26.

27 Krane M, Deutsch MA, Piazza N, *et al*. One-year results of health-related quality of life among patients undergoing transcatheter aortic valve implantation. *Am J Cardiol* 2012; 109: 1774–1781.

28 Mangen MJ, Bolkenbaas M, Huijts SM, *et al*. Quality of life in community-dwelling Dutch elderly measured by EQ-5D-3L. *Health Qual Life Outcomes* 2017; 15: 3.

29 Aaronson NK, Muller M, Cohen PD, *et al*. Translation, validation, and norming of the Dutch language version of the SF-36 Health Survey in community and chronic disease populations. *J Clin Epidemiol* 1998; 51: 1055–1068.