Minimally Invasive Repair of Pectus Excavatum

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Chapter 9

Early cost-utility estimation of surgical pectus excavatum correction with Nuss bar

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Abstract

Introduction
Surgical pectus excavatum correction with use of a Nuss bar provides satisfactory outcomes, but its cost-effectiveness is yet unproven. We prospectively analysed early outcomes and costs for Nuss bar placement.

Materials and Methods
Fifty-four patients of 16 years or older (6 females and 48 males) with a mean age of 17.9 years (range 16.0 -29.4 years) with a pectus excavatum had Short Form-36 Health Survey recorded pre-operatively and post-operatively after a Nuss procedure at 1 year.

Costs included professional fees, operating room, material costs and hospital care. Changes to the SF-36 or its domains were compared by the Wilcoxon signed rank test and utility calculated pre-operatively and post-operatively with the SF-6D. Derived from this the quality-adjusted life-years (QALY) were calculated.

Results
There were significantly improvements in physical functioning, social function, mental health and health transition (all $p<0.05$). The other SF-36 subgroups showed improvement however not significant.

The SF-6D utility showed improvement from 0.76 preoperatively to 0.79 at 1-year follow-up ($p= 0.096$). Mean direct costs were €8805. The 1 year discounted QALY gain was 0.03. The estimated cost-utility ratio was €293,500 per QALY gained.

Conclusions
Despite a significant improvement on many domains of the SF-36, the cost utility SF-6D results showed low cost-effective (>€80,000/quality adjusted life-year) improvement for pectus excavatum patients one year after Nuss bar placement. Based on this discrepancy, general health outcome measurements as basis for cost utility in PE patients maid not be the best way forward.

Introduction

The ever-increasing technological possibilities and hereby rising costs in health care systems make choices about limitation of treatment options inescapable [1]. A possible way to direct the limited resources toward treatments that have been shown to improve the quality of a patient's life is cost-utility analysis. This method can be used to assess the value of an intervention in terms of improving both quality and quantity of life [2]. This results in cost-effectiveness studies gaining in importance as stakeholders try to determine how to fairly distribute the limited health care budgets. In pectus excavatum, the most important anterior chest wall deformity predominantly occurring in males, a frequent treatment is surgical correction with a Nuss bar. This interventions does not increase life expectancy, but is rather aimed at improving the quality of life of these patients.

To describe the health improvement in this kind of surgical corrections one could use quality-adjusted life-years (QALYs), to indicate which health effects of an intervention are reasonable compared to its cost [3]. The utility score gives the opportunity to correct and therefore use this score in patients with a great variation in health states [4]. Many different health-related quality of- life instruments are used. All these questionnaires have in common the use of response to different domains on the areas of pain, physical, social and mental health [5]. The Short Form-36 Health Survey (SF-36) is a commonly used HRQL instrument. The scores of this questionnaire can be converted to a Short Form 6 Dimension (SF-6D) algorithm, which can be used for utility measurements [6]. The SF-6D consists of 6 different health domains: physical function, role limitations, social function, pain, mental health, and vitality and uses 11 questions of the SF-36 to assess these domains. For the SF-6D, the score ranges from 0.29 (lowest score in a living person) to 1 (perfect health). The SF-36 -6D is a standard validated means to translate the scores from the questionnaire into utilities, which can then be used for cost analysis [7]. It is commonly used for this purpose.

With regard to pectus excavatum surgical correction with a Nuss bar, there is no existing information concerning the cost-effectiveness of this procedure. Therefore, we prospectively analysed the outcomes and cost-utility of a serial cohort of Nuss procedures during a 1-year follow-up period.

Materials and methods

Patients and data

The study is based on a longitudinal cohort of pectus excavatum patients. The study cohort included 54 subjects (6 female, 48 male) with an average age of 17.9 years, treated with Nuss bar correction of their pectus excavatum. The number of included patients was not based on a sample size calculation since we did not make a comparison between possible treatments but were only interested in the cost effectiveness of this particular treatment method.

Inclusion criteria were age 16 years or older and pectus excavatum suited for treatment with Nuss bar. Marfan's syndrome or other associated connective tissue diseases were not an exclusion criteria, however in this study population no patients with connective tissue disease were included.

Exclusion criteria were insufficient knowledge of the Dutch language in reading or writing. All patients gave informed consent. The medical ethics committee approved the study.

Patients scheduled for pectus excavatum surgery, above the age of 16 years, with implantation of a Nuss bar between 2011 and 2016 were asked to fill in the SF-36 questionnaire preoperatively and 12 months after surgery. It is completed at more given times after surgery (being 6 months and 1-2-3-5 years), but for this analyses only the results pre-operatively and after 1 year are used. The Short Form-36 (SF-36) Health Survey questionnaire is a 36-item self-report inventory with eight dimensions of physical and mental domain, including Physical Functioning, Role–Physical, Bodily Pain, General Health, Vitality, Social Functioning, Role–Emotional, and Mental Health [8]. The SF-36 questionnaire has been found to have a robust predictive validity for health-related outcomes [9].

Concerning the score on the SF-6D the scores of those questions of the SF-36 that comprise the SF-6D are used to compute this score. This is a standard method and accepted world wide as a tool for cost effectiveness analysis.

The acquired data were stored in a protected SPSS database (SPSS Inc. Chicago, IL, USA).

In a previous paper we investigated the first small group of this study population on the association between pain and QoL [10].

Cost measures

Total direct medical costs were obtained for all included patients. These costs included a diagnosis-treatment-combination which also includes a certain percentage of complications during first admission. If patients had a complication that required redo surgery and / or re-admission, these separate costs were taken into account for the analyses presented here. The indirect costs were not estimated because nearly all patients were still students during the measurements. Fifty-four patients with PE diagnosed and treated during 2011–2016 were included. In the Netherlands patients with PE can be treated in paediatric surgical departments or thoracic surgical departments, the procedure does not differ per department and includes videothoracoscopy for all patients. Costs were adjusted by the consumer price index till 2017.

Cost data were retrieved from the hospital financial database. These included pre-operative outpatient clinic consultation, and the cost of inpatient hospital care (laboratory, radiology, operative procedures including implant, staff salaries, pharmacy, physiotherapy and if necessary other medical consultation). There were no significant differences observed between paediatric surgical and thoracic surgical departments.

Patients responses to the SF-36 questionnaire were transformed to SF-6D using SF-6D preference based algorithm licensed software (University of Sheffield, UK) to calculate the health utility value preoperatively and at one year postoperatively. This gives a preference-based utility index in which 1 is perfect health and 0 is equal to death [11]. QALYs were then calculated with the utility scores translated from the SF-6D [6].

Statistical analysis

Data analyses were conducted using IBM SPSS 23 software (SPSS Inc. Chicago, IL, USA). Descriptive statistics for variables of interest in this study are presented as percentage. Comparison between paired scores at measurement moment T1 and T2 for variables from the study group were calculated using Wilcoxon signed rank test. The cut off point for significance was set at $p < 0.05$.

Since no comparison was made between different treatment options a sample size calculation was not performed. The true costs of pectus excavatum correction with a Nuss bar were calculated. The calculated difference in health utility value, preoperative to 12 months postoperative using the SF-6D, was presumed to be totally caused by the surgical procedure. From that a QALY calculation was performed.

Next to that we described four often used (maximum) valuations per QALY to give a better oversight world round; €33,000, €42,000, €60,000 and €80,000, based on published acceptable cost per QALY in respectively England and Wales, USA, Italy and the Netherlands. We calculated the gain per QALY for treating pectus excavatum by Nuss bar implantation at one year post surgery.

Results

Fifty-four patients were available for follow-up. SF-36 subgroups showed significant improvement of physical functioning, social function, mental health and health transition (all $P < 0.05$). Although all domains showed improvement see Table1.

Table 1. Improvement preoperative to one year postoperative in SF-36 domains (N=54)

	Means preoperative	Means 1 year postoperative	p-value
Physical functioning	86.67	92.41	0.03
Social functioning	82.41	88.43	0.04
Mental health	71.63	76.30	0.01
Bodily pain	83.94	79.74	0.13
Vitality	66.30	67.96	0.46
General Health perceptions	73.70	77.04	0.18
Role limitations from physical health	80.56	86.57	0.16
Role limitations from emotional problems	79.63	80.86	0.90
Health transition	47.22	63.89	< 0.01
SF-6D index (utility) score	0.76	0.79	0.10

Means preoperative and 1 year postoperative of SF-36 domains. p-value calculated with Wilcoxon Signed Ranks Test.

The mean pre-surgical health utility value (SF-6D) was 0.76 and one year post-surgically it was 0.79, an average gain in health in one year of 0.03 QALY. This is around that what is considered the minimally important difference threshold [12]. Patients with pectus excavatum displayed a reduced HRQL, both preoperatively and postoperatively compared to healthy reference group data [13].

Mean direct costs were €8805 see Table 2. The estimated cost-utility ratio was € 293,500 per QALY gained [14]. We then calculated the economic gain after 12 months at QALY valuations of €33,000, €42,000, €60,000 and €80,000. Bringing the gain per QALY respectively to €990, €1260, €1800 and €2400.

Table 2. Costs associated with PE surgical correction with Nuss bar (N=54)

Outdoor clinic	1.0 %	€ 91.00
Hospitalization and medication	60.4 %	€5321.00
Surgical procedure and implant	34.4 %	€3029.00
Radiology	1.4 %	€ 124.00
Laboratory	1.3 %	€ 115.00
Miscellaneous	1.5 %	€ 125.00

Values are in percentage of total costs and total costs in Euro.

Surgery

Patients underwent surgery by a dedicated paediatric or thoracic surgeon. Mean operation time was 54.8 min (SD14.4) and mean hospital stay was 6.6 days (SD 1.4).

Complications

Total complication rate was 26%. There were 2 peroperative small perforations of the pericardium, which were managed conservatively. One bleeding of the mammary vessel with necessity of mini thoracotomy. A wound infection and one pneumonia both treated with antibiotics. There were three re-operations within one year, one for correction of early dislocation of the Nuss bar and two for chronic pain near the location of the stabiliser, for which one stabiliser was removed. All other complications (sensibility changes) were due to the use of epidural pain management and self-limiting after discontinuing of the epidural. The one year mortality was zero.

Discussion

Overall knowledge and skills seem to have improved over the recent decades in using the Nuss bar for the correction of PE [15]. On the area of cost-effectiveness however of this surgical treatment little is known. There is a study addressing the reduction of hospitalization costs in surgical corrected PE patients by using a minimal invasive technique [16]. A cost-utility analysis could address this void. Therefore we analysed a cohort of patients with PE undergoing this procedure.
Cost-utility analyses are increasingly used to compare the costs of medical treatments to decide which procedure is economically acceptable. In order to take also patient preferences into account it is expressed as utilities or QALY in calculations.

For our study individual treatment costs were identified for all patients from the study group. Direct costs were subtracted from the financial systems of the hospitals, whereby small differences in specific costs may exist due to local contracts with health insurance companies. These differences are too small to have any real impact. Costs did not include indirect costs, such as transportation or loss of production and patient income, however it should be noted that the patients group existed mainly of high school attendance and students. Theoretically any indirect cost would lead to an increase in total costs and subsequently to a higher amount of the estimated cost-utility ratio.

Next to that patients filled in the SF-36 before surgery and after one year. All SF-36 subgroups as role limitations due to physical health and emotional problems, bodily pain, vitality and general health showed improvement, but only physical functioning, social function, mental health and health transition were significantly improved. SF-36 is a highly validated questionnaire widely applied in medical evaluations, where it reflects a broad and general appreciation of physical and mental functioning. The improvement on all levels in our study did not lead to a large increase in the calculated SF-6D index score. Earlier reports show lower results with the SF-6D than with the EQ-5D, which also gives a larger improvement in utility in patients who start out in low disability state before having surgery[17]. The result of this relatively low SF-6D score leads to high costs per QALY, suggesting a small change of this intervention for this group of patients. This is actually contrary to the larger changes taken place in the different domains of the SF-36. Where there are significant positive changes in physical-, mental- and social function, which should lead to an improvement of

self-esteem and body-image of the patients. Since body-image is lowered before surgery in a pectus population compared to a matched healthy population and in adolescents related to their direct well-being, restoration of body-image seems to be an important goal [18,19,20]. Nearly the same applies for self-esteem. Particularly because restoring self-esteem leads to positive affect and a better capability to cope with life and its challenges [21,22]. However the SF-36 is a health related quality of life measurement (HRQOL) and although very good in detecting functional changes, it's less in detecting changes in patients satisfaction. Especially the improvement in domains as markers of patient satisfaction (body image, self-esteem) might be more important than overall improvement in HRQOL or health utility score itself. As long as cost-effectiveness is an expression of (improvement of) physical functioning it will be difficult to prove the use of surgery / treatment with a main focus on body image and/or self-esteem when looking at the costs or the QALY's.

Costs of improvement after surgery can be calculated, but what are acceptable cost-effectiveness levels is different around the world. Certain countries have an established thresholds of what they see as cost-effective for a QALY such as £20,000 – £30,000 in the United Kingdom, $50,000 per QALY in the US, Italy €60,000 and the Netherlands €80,000 per QALY. The World Health Organization however uses a different formula based on the gross domestic product (GDP) per capita. Threshold values of less than capita are highly cost-effective, while between 1 and 3 times the GDP per capita is noted as cost-effective, and health interventions costing more than 3 times the GDP per capita are considered not cost-effective [23]. Instead others recommend that analysts use $50,000, $100,000, and $200,000 per QALY as a more reasonable figure [24]. However other countries for example Belgium, Denmark, Norway Sweden and Finland do not define a threshold value, since they find the basis for these thresholds unclear [25]. For our calculations we used the four general levels in euro's.

In our study, we prospectively gathered costs and outcome scores for a specific group of patients undergoing PE correction. Although the QALY improved at 1 year by the SF-6D calculation, it missed statistical significance (p=0.096). We have not found any other study that examined the cost-utility of Nuss bar placement nor the real costs. Our mean direct costs were calculated at €8805. Although differences in costs among hospitals in the Netherlands may exist, they will be very small.

We also calculated the economic increase with different levels of QALY values used around the world of €33,000, €42,000, €60,000 and €80,000. Bringing the gain per QALY on basis of 0.03 increase in SF-6D score to respectively to €990, €1260, €1800 and €2400. Since it could be reasoned that this would account for the whole period that the Nuss bar is in situ (3 years) by the same SF-6D score, the costs could be spread over this 3 years. Under theoretical assumption that there would not be any other change the gain per QALY would increase to respectively €2970, €3780, €5400 and €7200.

One should keep in mind that the Nuss bar placement is usually followed after a period of approximately three year postoperative, by removal of the Nuss bar operatively usually in daytime surgery. This will after three years add to the costs of the treatment and thereby affect the overall costs of the treatment of pectus excavatum with a Nuss bar. However, it may be that the removal of the bar also has some additional effect on the functional outcome and thus lead to a small increase in cost-utility. Although in the study design patients do complete the SF-36 after bar-removal we decided not to wait for these results since we do not expect an significant increase in functioning after removal.

Estimation of the cost-utility ratio under assumption of a three years period would lead to € 97,833 costs per QALY gained. However since the patient population is very young and has a long life expectancy, they could profit for decades from the surgical improvement from their chest wall, something that is not clearly visible in the results of the utility gain nor in the calculations [26].

Although the cost analysis in this study reflects the health related economics in the Netherlands, which is different from other countries, the study does provide data of the SF-36 and SF-6D which should allow surgeons around the world to use and adjust for the measurement of cost-utility in their specific surroundings. This study does show that pectus excavatum correction with a Nuss bar is not cost-effective after 1 year in the Netherlands or in the high-cost environment of the United States and also not cost-effective in large parts of the rest of the world if QALY's are calculated on base of the SF-6D.

The percentages from Table 2 reflect real costs from the care process around PE patients undergoing Nuss procedure. It will be interesting to re-evaluate our patients after approximately 3 years when the Nuss bars get removed, to determine whether the SF-6D scores (QALY) improvements are truly long lasting.

Conclusion

Surgically treatment of pectus excavatum in adolescents or young adults with a Nuss bar gives a health benefit for a range of domains of the SF-36. However the costs exceed on short term the acceptable costs per QALY in the Netherlands as elsewhere around the world based on the SF-6D. However since the benefit should stay life-long, therefore the measured gain in quality of life after only one year makes it difficult to draw firm conclusions about the cost effectiveness of the procedure. To appreciate and value the important improvement in self-esteem and body image, a way to better weight patient satisfaction in QALY's is desirable next to the well-known present HRQOL questionnaires.

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