Quality-of-Life Assessment of Fibroid Treatment Options and Outcomes¹

Fiona M. Fennessy, MD, PhD
Chung Yin Kong, PhD
Clare M. Tempany, MD
J. Shannon Swan, MD

Purpose:

To obtain utilities (a unit of measure of a person's relative preferences for different health states compared with death or worst possible outcome) for uterine fibroids before and after treatment and to measure short-term utilities for the following uterine fibroid treatments: abdominal hysterectomy, magnetic resonance (MR) imaging-guided focused ultrasound surgery, and uterine artery embolization (UAE).

Materials and Methods:

This retrospective study was approved by the institutional review board and was HIPAA compliant. The waiting trade-off (WTO) method, a variation on the time trade-off (TTO) method, is used to obtain utilities for diagnostic procedures on the basis of the fact that people wait longer to avoid noxious tests and/or procedures. The WTO method provides short-term quality of life tolls in terms of quality-adjusted life-weeks by scaling wait times with pre- and posttreatment utilities. Utilities for uterine fibroids before and after treatment were obtained with the TTO method and a visual analog scale (VAS) by using a questionnaire administered by means of a phone interview. WTO wait times were adjusted for quality of life with VAS and TTO utilities and a transformation of VAS. Wait times were compared by using nonparametric tests. The study participants included 62 patients who had undergone abdominal hysterectomy, 74 who had undergone UAE, and 61 who had undergone MR imaging-guided focused ultrasound surgery.

Results:

Quality of life increased with all treatments. The median WTO wait time was higher for hysterectomy (21.6 weeks) than for UAE or MR imaging-guided focused ultrasound surgery (14.1 weeks for both) ($P < .05$). Quality-adjusted life-week tolls were smaller when scaled according to TTO than when scaled according to VAS or transformation of VAS.

Conclusion:

Quality of life increased after all fibroid treatments. WTO is feasible for assessing the quality-adjusted morbidity of treatment procedures.

©RSNA, 2011

Supplemental material: <http://radiology.rsna.org/lookup/suppl/doi:10.1148/radiol.11100704/-/DC1>

¹From the Department of Radiology, Brigham and Women's Hospital, Harvard Medical School, 75 Francis St, Boston, MA 02115 (F.M.F., C.M.T.); and Institute for Technology Assessment, Massachusetts General Hospital, Harvard Medical School, Boston, Mass (C.Y.K., J.S.S.). Received April 6, 2010; revision requested June 10; revision received September 17; accepted October 15; final version accepted December 15. F.M.F. supported by General Electric AUR Radiology Research Academic Fellowship (GERRAF).

Address correspondence to F.M.F. (e-mail: ffennesy@partners.org).

© RSNA, 2011

Uterine fibroids (leiomyomas) are the most common pelvic tumors and are a substantial cause of morbidity for women of reproductive age (1). They are the largest single indication for hysterectomy and account for substantial health care costs (2,3). Perhaps motivated by a trend toward later childbearing and a preference for a short recovery time, women are increasingly seeking minimally invasive alternatives to hysterectomy. Consequently, there has been a rapid growth in minimally invasive uterine artery embolization (UAE) programs (4). Magnetic resonance (MR) imaging-guided focused ultrasound surgery is a recent noninvasive

treatment option that uses a combination of MR image guidance and energy delivery. Symptom reduction with an excellent safety profile has been seen with MR imaging-guided focused ultrasound surgery (5–10), and it has been cleared by the Food and Drug Administration for the treatment of uterine fibroids. For MR imaging-guided focused ultrasound surgery to be widely adopted, however, it must be deemed as beneficial as the established alternatives, and cost-utility analysis is integral to this assessment. In addition to comparing the costs of technologies, the change in health outcome is also compared in cost-utility analysis. The unit that is commonly accepted as the best measure of benefit from a health care intervention is the “utility” weight. A utility weight is a single unit of preference that encompasses all the different benefits from a health care intervention. The value assigned resides on a scale where 0 = death and 1.0 = perfect, optimal, or “full” health (11). The outcome of any health intervention can then be calculated as the product of an increase in utility and the time over which this increase may be enjoyed.

To our knowledge, no utility values specific to uterine fibroid symptoms have been identified to date. The utility assigned to fibroid symptoms in economic analysis is often that of menorrhagia (12,13), although other symptoms such as urinary frequency, pain, or bulk symptoms may lead patients to seek treatment. In addition, it has been shown that negative experiences associated with procedures or treatments in general may influence the cost-effectiveness of one procedure over another by means of a reduction in the short-term quality-adjusted life expectancy (14–17). In other words, if patients believe a parti-

cular procedure or treatment to be very unpleasant, short-term assessment of the utility weight during this period may be negative enough to impact the overall “effectiveness” of the procedure. Therefore, short-term utilities for fibroid treatment procedures are potentially relevant.

We performed this study to (a) obtain utilities for uterine fibroids before and after treatment and (b) measure short-term utilities for the following uterine fibroid treatments: abdominal hysterectomy, MR imaging-guided focused ultrasound surgery, and UAE.

Advances in Knowledge

- Quality of life significantly increases after a range of fibroid treatment options—from invasive (abdominal hysterectomy), to minimally invasive (uterine artery embolization [UAE]), to noninvasive (MR imaging-guided focused ultrasound surgery); the mean visual analog scale score ($\pm$ standard deviation) increased from 0.525 ± 0.241 to 0.934 ± 0.110 for hysterectomy, from 0.543 ± 0.235 to 0.785 ± 0.222 for UAE, and from 0.569 ± 0.205 to 0.672 ± 0.237 for MR imaging-guided focused ultrasound surgery, and the mean time trade-off preferences increased from 0.766 ± 0.4 to 0.986 ± 0.1 for hysterectomy, from 0.819 ± 0.3 to 0.92 ± 0.2 for UAE, and from 0.860 ± 0.2 to 0.925 ± 0.1 for MR imaging-guided focused ultrasound surgery.
- Patients who underwent hysterectomy would be willing to wait significantly longer with symptoms (21.6 weeks) to avoid that procedure compared to patients in the other treatment groups, who would wait 14.1 weeks to avoid the morbidity associated with their chosen procedure; this finding indicates patient preference for minimally invasive and/or noninvasive treatment options.

Implication for Patient Care

- The findings in this study may provide measures to aid in future cost-utility analyses of uterine fibroid treatments and may be helpful in patient, physician, and institutional decision making with regard to uterine fibroid treatment options.

Materials and Methods

This retrospective study was approved by our institutional review board and was compliant with the Health Insurance Portability and Accountability Act. Respondents who were treated with MR imaging-guided focused ultrasound surgery were part of a clinical trial. InSightec (Haifa, Israel) funded and provided the equipment for this trial. Authors who were not consultants for InSightec had control over inclusion of

Published online before print

10.1148/radiol.11100704

Radiology 2011; 259:785–792

Abbreviations:

TTO = time trade-off

tVAS = transformation of VAS preferences to TTO preferences

UAE = uterine artery embolization

U_{base} = current baseline utility

U_{state} = utility for uterine fibroid health state

VAS = visual analog scale

WTO = waiting trade-off

Author contributions:

Guarantor of integrity of entire study, F.M.F.; study concepts/study design or data acquisition or data analysis/interpretation, all authors; manuscript drafting or manuscript revision for important intellectual content, all authors; manuscript final version approval, all authors; literature research, F.M.F., J.S.S.; clinical studies, F.M.F., C.M.T.; statistical analysis, F.M.F., C.Y.K., J.S.S.; and manuscript editing, all authors

Funding:

This research was supported in part by the National Institutes of Health (grant U41-RR019703).

Potential conflicts of interest are listed at the end of this article.

any data and information submitted for this study.

Patient Population

The study population consisted of patients with symptomatic uterine fibroids treated with hysterectomy, UAE, or MR imaging-guided focused ultrasound surgery at our institution between January 2004 and December 2006. Consecutive patients who underwent UAE and MR imaging-guided focused ultrasound surgery were selected from our radiology case database. Consecutive patients who underwent hysterectomy were selected after retrospective identification of willing patients by gynecologists, who subsequently gave us permission to contact their patients. All patients were sent a recruitment letter from their specialist health care provider to participate in our study, and the interview script (Appendix E1, online) was provided before the interview.

Administration of Instruments

All assessments used a Visual Basic application (Microsoft, Redmond, Wash) during a single telephone call, as implemented previously (15). The interviewer (one of whom was F.M.F.) was guided to execute the choice-based (waiting trade-off [WTO] or time trade-off [TTO]) assessments in a consistent fashion by means of an algorithm presented from the Visual Basic interface and an interview script (Appendix E1, online).

Chronic Utilities for Fibroids

We used a visual analog scale (VAS) adapted from the EQ 5D (18) and TTO assessment as our utility measures, as outlined in Appendix E1 (online). The VAS (0 = death, 100 [or 1.0] = perfect or optimal health) was chosen because it is easy to comprehend and implement. It is sensitive to changes in health status and provides reliable measures of health utility (11). VAS values were obtained for the health state of having uterine fibroids and for a posttreatment current baseline value. The VAS was also used to suggest validity of the direction of preference determined with the TTO method.

The TTO is a choice-based method developed specifically for use in health care (19,20) and asks respondents to value their health status by means of a trade-off exercise of life for gains in health status. The patient decides between a longer life in the less-optimal health state (with fibroid-related symptoms) versus a shorter life in symptom-free health. In other words, if the respondent considered her disease to be mild and tolerable, she would be very unlikely to be willing to trade off life and would choose a longer life, even in a less than optimal health state. If, however, the respondent found her symptoms to be intolerable, she may choose a shorter symptom-free life over a longer life with symptoms. A 10-year time horizon was chosen as the maximum time in less-optimal health because the average age ($\pm$ standard deviation) of patients in our study presenting for treatment was 46.74 years $\pm$ 4.9 and the reported average age for menopause is 51 years (21). After a maximal 10-year time horizon, it would be assumed that all patients would reach menopausal status and no longer be in need of fibroid treatment.

The calculated utility for uterine fibroid health state (U_{state}) by using the TTO was obtained by asking the respondent to recall fibroid symptoms and how they affected her life (Appendix E1, online). Patients assumed a life expectancy of 10 years, following which they would have a painless death. The lower boundary of the scale was conservatively set at 1 month, as no assumption was made as to how debilitating the respondent considered her disease to be. In other words, we did not assume that patients with this benign condition would not wish to trade off large amounts of lifetime for a short period of being free of symptoms. They were given the choice of spending those 10 years living with the same level of fibroid-related symptoms they had before treatment versus spending the next 10 years symptom-free. Patients would rationally take the second alternative. Patients were then given the option of choosing 1 month completely symptom-free, followed by death, as opposed to

10 years with fibroid-related symptoms, followed by death. If they answered "yes" to the first option, the lower boundary was met and the assessment stopped. If they answered "no," the queries continued with bisection of symptom-free time intervals until indifference to the choices was obtained between 1 month and 10 years. U_{state} was determined by dividing the point of indifference between the choices by 10 (eg, an indifference point of 9 years symptom-free gives a utility of $9/10 = 0.9$).

A posttreatment or current baseline utility (U_{base}) was obtained similarly by focusing on current fibroid-related symptoms (or lack thereof) that occurred on a daily basis after treatment. The current baseline utility for each respondent was calculated by dividing the time in fibroid symptom-free health at the indifference point by 10.

Short-term Utility Analysis for Uterine Fibroid Treatment Procedures

WTO.—We adapted the WTO (14) to elicit utilities for the short-term health states experienced during the treatment procedure. Previously used in assessing patient preferences for diagnostic tests (15,22), the WTO is framed as a willingness to wait longer with symptoms for results of a hypothetical "ideal" test to avoid a more noxious test experience. The WTO can provide a short-term quality-adjusted life-year "toll" (deducted from quality-adjusted life expectancy in cost-utility analysis) to reflect the morbidity of testing.

In our WTO adaptation, respondents compared the treatment that they had with a hypothetical "ideal" risk-free, pain-free procedure of negligible length but with similar efficacy. They were asked to trade off a given amount of extended time with symptoms to avoid the noxious experiences of the actual treatment they underwent. Because fibroid symptom relief occurs as early as 3 months after therapy (10), the interview began with a hypothetical wait time of 12 weeks for symptom relief with the ideal treatment and then used a similar bisection approach to that used with TTO (Appendix E1, online). The expectation, shown with the WTO in testing, is that the

longer the patient was willing to wait for symptom relief after the ideal treatment, the worse they judged the actual treatment to be.

In the case of MR imaging–guided focused ultrasound surgery, patients from whom a definitive wait time could not be obtained but who indicated that they “would never undergo the procedure” were assigned the maximum wait time that was given by a patient in that treatment group (104 weeks). Analyses were also repeated when outliers were assigned time until the average age to menopause as their wait time and when they were totally excluded from the analysis. A chart review of these patients was performed to determine a potential cause for such responses.

Quality-adjusted life-weeks toll.—As outlined in Figure 1, the toll on utility or “disutility” of treatment in quality-adjusted life-weeks was calculated as $(t_2 - t_1) \times (U_{\text{base}} - U_{\text{state}})$, where t_2 is the time the individual is willing to wait to avoid the treatment procedure and t_1 the time when the procedure ends. Thus, a quality-adjusted life-week toll was calculated by rescaling the raw wait time with mean utility values for fibroid symptoms and for the current treated state, which were obtained by using three different techniques: a conventional TTO method, VAS, and transformation of VAS preferences to TTO preferences (tVAS). The latter was obtained by means of a known power function used to convert group mean VAS scores to TTO, as follows: $1 - (1 - \text{group mean VAS score})^{1.53}$ (20,23,24).

Statistical Analysis

Statistical analysis was performed by using software (SPSS Statistics for Windows, version 18, SPSS, Chicago, Ill; and MedCalc, version 11.2, MedCalc, Mariakerke, Belgium). Nonparametric tests were used as the data distributions were inspected in histograms, which were similar in shape and showed a high frequency of responses in the lower left part of the curve (indicating a relatively benign health state scenario), with a tail to the right. VAS and TTO utilities before and after treatment were compared by using the Wilcoxon signed

Figure 1

Figure 1: Graph illustrates how the short-term disutility of a test or treatment procedure (as defined with the WTO) is calculated. Disutility = $(t_2 - t_1)(U_{\text{base}} - U_{\text{state}})$, where t_1 is the time when procedure ends and t_2 , the time the individual is willing to wait to avoid the test or treatment procedure. The area of rectangle outlined by a, b, c, and d defines the disutility being measured. t_0 = time when procedure begins.

Table 1

Recruitment Results

Parameter	Hysterectomy	UAE	MR Imaging–guided Focused Ultrasound Surgery
Total letters sent	159	141	97
No. of patients who completed survey	62	74	61
No. of patients unwilling to participate	8	10	13
No. of patients willing to participate but unable to find suitable time for survey	12	16	11
No. of patients who could not be reached owing to incorrect address/phone number	77	33	12
No. of patients in whom the procedure was not performed owing to uterine fibroids	0	8	0

rank test. Only paired VAS and TTO data were used in this analysis. The wait times between each treatment group were compared by using the Kruskal-Wallis method with post hoc tests as described by Conover (25). Spearman correlations were used to assess trends between VAS and TTO data after treatment, and $P \leq .05$ was indicative of a statistically significant difference.

Results

Recruitment letters were sent to 159 patients who had undergone hysterectomy, 141 who had undergone UAE, and 97 who had undergone MR imaging–guided focused ultrasound surgery. Recruitment results are presented in Table 1. Completed surveys were ob-

tained from 62 of the 82 patients (76%) who underwent hysterectomy and with whom contact was made, 74 of the 100 (74%) who underwent UAE, and 61 of the 85 (72%) who underwent MR imaging–guided focused ultrasound surgery (Table 2). The mean ages ($\pm$ standard deviation) of responders and non-responders were 47.38 years $\pm$ 4.14 and 46.61 years $\pm$ 5.62, respectively, for patients who underwent MR imaging–guided focused ultrasound surgery, 44.76 years $\pm$ 5.17 and 43.88 years $\pm$ 6.27 for patients who underwent UAE, and 47.77 years $\pm$ 5.22 and 46.38 years $\pm$ 5.38 for patients who underwent hysterectomy. The mean time between the procedure and survey was 3.82 years $\pm$ 0.69 for MR imaging–guided focused ultrasound surgery, 1.77 years

Table 2

Number of Respondents Who Completed Components of the Questionnaire

Treatment Group	VAS		TTO		WTO
	Before Treatment	After Treatment	Before Treatment	After Treatment	
Hysterectomy (<i>n</i> = 62)	62	62	61	62	60
UAE (<i>n</i> = 74)	74	74	72	73	72
MR imaging–guided focused ultrasound surgery (<i>n</i> = 61)	61	61	60	59	61*

* Includes four respondents who stated they “would never undergo MR imaging–guided focused ultrasound surgery.” These patients were assigned the maximum wait time of their group.

Table 3

VAS Scores before and after Treatment

Treatment Group	VAS Score*		<i>P</i> Value†
	Before Treatment	After Treatment	
Hysterectomy (<i>n</i> = 62)	0.525 ± 0.241	0.934 ± 0.110	<.001
UAE (<i>n</i> = 74)	0.543 ± 0.235	0.785 ± 0.222	<.001
MR imaging–guided focused ultrasound surgery (<i>n</i> = 61)	0.569 ± 0.205	0.672 ± 0.237	<.001

* Data are given as means ± standard deviations.

† *P* values were obtained with the Wilcoxon signed rank test and reflect differences in VAS scores obtained before versus after treatment.

Table 4

TTO Preferences before and after Treatment

Treatment Group	TTO Value*		<i>P</i> Value†
	Before Treatment	After Treatment	
Hysterectomy (<i>n</i> = 61)	0.766 ± 0.351	0.986 ± 0.067	<.001
UAE (<i>n</i> = 72)	0.819 ± 0.262	0.920 ± 0.204	<.001
MR imaging–guided focused ultrasound surgery (<i>n</i> = 59)	0.860 ± 0.239	0.925 ± 0.128	.002

* Data are given as means ± standard deviations.

† *P* values were obtained with the Wilcoxon signed rank test and reflect differences in TTO values obtained before versus after treatment.

± 1.53 for UAE, and 1.95 years ± 1.17 for hysterectomy. The time between the procedure and survey was significantly greater for patients who underwent MR imaging–guided focused ultrasound surgery than for those who underwent UAE or hysterectomy (*P* < .005, unpaired *t* test).

Before and after treatment, the group VAS values were lower than the TTO preferences. Both the VAS values and

the TTO preferences increased significantly after treatment for all three treatment groups (Tables 3, 4). After treatment, there was a greater diversity in VAS scores as opposed to TTO preferences. When the results for VAS and TTO were compared, there was an apparent reversal of rank order of treatment preference between VAS and TTO for UAE and MR imaging–guided focused ultrasound surgery. There was a

Table 5

Correlation between TTO and VAS Values after Treatment

Treatment Group	Spearman Correlation	
	Coefficient (<i>p</i>)	<i>P</i> Value
Hysterectomy	0.334	.002
UAE	0.560	<.001
MR imaging–guided focused ultrasound surgery	0.490	<.001

significant positive correlation between the posttreatment TTO and VAS values (Table 5).

In assessing the disutility of treatment procedures with use of the WTO, four of the 61 respondents who underwent MR imaging–guided focused ultrasound surgery answered that they “would not undergo MR imaging–guided focused ultrasound surgery” or “would never have it.” We noted that no matter how these outliers were treated, the overall pattern and significance of the wait times for MR imaging–guided focused ultrasound surgery versus UAE and hysterectomy did not change. A review of the charts of these patients found that one patient had a vasovagal response, one had positional-related discomfort during the procedure, and one believed the treatment to be ineffective; the fourth patient reported fibroid symptom relief up to 2 years after treatment. Although it is possible that such responses are credible in patients not willing to trade off time, these patients were part of early clinical trials (Insightec UF002 and UF005) and were treated under more restrictive guidelines than were those included in later trials.

Wait times indicated that patients who underwent hysterectomy judged that experience to be significantly worse than did those who underwent UAE and MR imaging–guided focused ultrasound surgery (*P* = .01, post hoc test; *P* < .05 for hysterectomy vs UAE and hysterectomy vs MR imaging–guided focused ultrasound surgery; Fig 2). The quality-adjusted life-weeks toll was smaller when raw wait time was scaled with TTO

as opposed to tVAS and VAS for all patient groups (Fig 3).

Discussion

The choice of fibroid treatment is dependent on symptoms, location, burden, cost, patient preference, and quality of life implications. Expressed in terms of dollars per quality-adjusted life-years, cost-utility analysis defines the best treatment option as that which gains the most quality-adjusted life-years with the least cost. Quality-adjusted life-years are subjective and are based on a patient's preference for states of health.

Because no utility values specific to uterine fibroid symptoms have been reported, cost-utility analysis studies to date presumed the utility to be the same as that of menorrhagia (13,26) or a utility weight was estimated from health state questionnaires (27). Although this indirect method of determining preference is popular (28), there are criticisms with regard to the validity of utilities generated and to their lack of sensitivity in various disease states (29–31). Such methods do not measure patient preferences directly, and differences have been found in utility scores derived from different instruments (32,33). Our study directly obtained utility values for fibroid symptoms before and after three treatment options, and this may provide for more robust future fibroid cost-utility analysis.

Both TTO preferences and VAS values increased significantly after treatment for all treatment groups. Group VAS results were lower than TTO preferences, and this is consistent with findings in the utilities literature (11,24,28,34). This difference can be explained by the fact that TTO requires a trade-off among choices (respondent is required to determine the amount of time they are willing to give up to avoid an impaired health state). Conversely, no life consequences are linked to the VAS, a “choiceless” utility (35). In our study, respondents may not have considered fibroid disease dire enough to be willing to trade off time and so gave higher TTO utilities. Therefore, a “plateau effect” can be seen with the TTO (36), where

Figure 2

Figure 2: Bar chart shows the mean and median raw wait times for each treatment group. Data were obtained from 60 of the 62 patients who had undergone hysterectomy (HYST), 72 of the 74 patients who had undergone UAE, and all 61 patients who had undergone MR imaging–guided focused ultrasound surgery (MRgFUS). * = $P < .05$ versus hysterectomy with Kruskal-Wallis method with post hoc test, which indicates the significant disutility of hysterectomy as compared with the other procedures.

the VAS value must decrease a certain amount before time will be traded with the TTO. The result can be a large “ceiling effect,” where TTO preferences are all crowded closer to 1.0 and thus differences in health states are smaller than those estimated by using a VAS. It is possible that skewing of the TTO data occurred in our case. Given this finding, a reversal between the VAS versus TTO posttreatment rank order of treatment preference could occur.

Furthermore, it is possible that there was a heterogeneous spectrum of disease across groups. Heterogeneity of disease could be evaluated with a uterine fibroid–specific quality of life instrument such as the Uterine Fibroid Symptom and Quality of Life questionnaire (37), although reported baseline fibroid symptom scores in UAE studies (38) and MR imaging–guided focused ultrasound surgery studies (10) are similar. If the possibility of heterogeneous disease is considered, trade-off behavior could be variable and comparisons may be most meaningful within groups before and after treatment. Considering this limitation, the utility data obtained in our study may still offer a more

Figure 3

Figure 3: Bar chart shows the resulting quality-adjusted life-week (QALW) tolls when raw wait times are adjusted by using the TTO, transformation of VAS scores to TTO values (tVAS to TTO), and the VAS scores for each treatment group. Quality-adjusted life-week values were calculated as (mean wait time) $\times$ (TTO score after treatment – TTO score before treatment) for TTO, as (mean wait time) $\times$ (tVAS coefficients after treatment – tVAS coefficients before treatment) for tVAS, and as (mean wait time) $\times$ (VAS score after treatment – VAS score before treatment) for VAS. HYST = hysterectomy, MRgFUS = MR imaging–guided focused ultrasound surgery.

accurate utility value for uterine fibroid cost-utility analyses, compared to using a utility value for menorrhagia before treatment or assuming the patient to be symptom-free after treatment. In addition, the short-term utilities for treatments obtained with the WTO can offer additional measures for inclusion in cost-utility analysis.

It is also important to recognize potential difficulties of incorporating death into TTO decision making for patients with this benign condition. If we consider the higher preferences obtained by using TTO compared with VAS, it would appear that subjects did in fact recognize that a trade in lifetime and a need to incorporate death were involved in their decision making.

The assessment of health utilities has traditionally focused on chronic disease states. However, utilities for health states during procedures or diagnostic tests are becoming important factors to

consider in cost-utility analysis (15,16,22,39,40). A measure of patients' willingness to wait to avoid a more noxious experience, the WTO provides short-term quality-adjusted life-year tolls for a disease state. Our study demonstrated that the WTO is feasible for obtaining short-term treatment utilities. As expected, the unscaled wait time for hysterectomy is significantly greater than that for both UAE and MR imaging-guided focused ultrasound surgery, indicating that patients who underwent hysterectomy would (in retrospect) be willing to wait longer to avoid a hysterectomy. Our results therefore indicate patient preference for minimally invasive or noninvasive treatments over traditional abdominal hysterectomy.

Better discrimination of UAE versus MR imaging-guided focused ultrasound surgery may require a larger sample. We used three approaches for scaling the wait time. Considering the relative benignity of the disease state of uterine fibroids, it is possible that VAS and tVAS may best scale a change in raw wait time preferences among the ranges in treatment options. Thus, the WTO in such a circumstance becomes a hybrid of a choice-based measure and a VAS.

A definitive wait time could not be obtained in four patients who underwent MR imaging-guided focused ultrasound surgery, with all four patients indicating that they would not undergo the procedure. Although not wishing to commit to a definite wait time is a risk in TTO-based assessment, it is remarkable that all four patients were treated with MR imaging-guided focused ultrasound surgery and, thus, were potentially part of the "learning curve" associated with the introduction of new technologies.

A limitation of this study is the absence of patients who were treated with laparoscopic and vaginal hysterectomy or myomectomy. However, we obtained preference measures for patients who chose the most invasive (hysterectomy) to noninvasive (MR imaging-guided focused ultrasound surgery) treatment options, providing a range of utility values for patients with symptomatic fibroids. In addition, it is noteworthy that

the time between the survey and procedure was significantly greater for the patients who underwent MR imaging-guided focused ultrasound surgery. Although we noted no difficulty in patients being able to recall their experience, there is a possibility of recall bias; there is no way to conclusively evaluate the effect of elapsed time on recalled experiences. There is also the possibility that treatment selection was biased by fibroid burden. Although we did not calculate fibroid size in this study, it should be noted that large fibroid size was not a contraindication to MR imaging-guided focused ultrasound surgery in these early clinical trials (patients with uterine size of ≤ 24 weeks were treated).

In conclusion, the health utility values obtained in this study suggest that all of the evaluated treatments for uterine fibroids increased the quality of life and that the perceived morbidity of treatment procedures varied, all of which may inform more robust cost-utility analyses of fibroid treatment.

Acknowledgments: We thank Louise Greenberg, MEd, Richard A. Baum, MD, MPA, and Raymond J. Reilly, MBBCH.

Disclosures of Potential Conflicts of Interest:

F.M.F. Financial activities related to the present article: none to disclose. Financial activities not related to the present article: none to disclose. Other relationships: none to disclose. **C.H.K.** Financial activities related to the present article: none to disclose. Financial activities not related to the present article: none to disclose. Other relationships: none to disclose. **C.M.T.** Financial activities related to the present article: receives a consulting fee or honorarium from InSightec; institution received money from InSightec for clinical trial support. Financial activities not related to the present article: none to disclose. Other relationships: none to disclose. **J.S.S.** Financial activities related to the present article: none to disclose. Financial activities not related to the present article: none to disclose. Other relationships: none to disclose.

References

1. Stewart EA. Uterine fibroids. *Lancet* 2001; 357(9252):293-298.
2. Flynn M, Jamison M, Datta S, Myers E. Health care resource use for uterine fibroid tumors in the United States. *Am J Obstet Gynecol* 2006;195(4):955-964.
3. Hartmann KE, Birnbaum H, Ben-Hamadi R, et al. Annual costs associated with diagnosis of uterine leiomyomata. *Obstet Gynecol* 2006;108(4):930-937.
4. Committee on Gynecologic Practice, American College of Obstetricians and Gynecologists. ACOG Committee Opinion. Uterine artery embolization. *Obstet Gynecol* 2004; 103(2):403-404.
5. Fennessy FM, Tempany CM. MRI-guided focused ultrasound surgery of uterine leiomyomas. *Acad Radiol* 2005;12(9):1158-1166.
6. Fennessy FM, Tempany CM. A review of magnetic resonance imaging-guided focused ultrasound surgery of uterine fibroids. *Top Magn Reson Imaging* 2006;17(3):173-179.
7. Lénárd ZM, McDannold NJ, Fennessy FM, et al. Uterine leiomyomas: MR imaging-guided focused ultrasound surgery—imaging predictors of success. *Radiology* 2008;249(1): 187-194.
8. Stewart EA, Rabinovici J, Tempany CM, et al. Clinical outcomes of focused ultrasound surgery for the treatment of uterine fibroids. *Fertil Steril* 2006;85(1):22-29.
9. Tempany CM, Stewart EA, McDannold N, Quade BJ, Jolesz FA, Hynynen K. MR imaging-guided focused ultrasound surgery of uterine leiomyomas: a feasibility study. *Radiology* 2003;226(3):897-905.
10. Fennessy FM, Tempany CM, McDannold NJ, et al. Uterine leiomyomas: MR imaging-guided focused ultrasound surgery—results of different treatment protocols. *Radiology* 2007;243(3):885-893.
11. Froberg DG, Kane RL. Methodology for measuring health-state preferences. II. Scaling methods. *J Clin Epidemiol* 1989;42(5): 459-471.
12. Fryback DG, Dasbach EJ, Klein R, et al. The Beaver Dam Health Outcomes Study: initial catalog of health-state quality factors. *Med Decis Making* 1993;13(2):89-102.
13. Hurskainen R, Teperi J, Rissanen P, et al. Quality of life and cost-effectiveness of levonorgestrel-releasing intrauterine system versus hysterectomy for treatment of menorrhagia: a randomised trial. *Lancet* 2001; 357(9252):273-277.
14. Swan JS, Fryback DG, Lawrence WF, Sainfort F, Hagenauer ME, Heisey DM. A time-tradeoff method for cost-effectiveness models applied to radiology. *Med Decis Making* 2000;20(1):79-88.
15. Swan JS, Lawrence WF, Roy J. Process utility in breast biopsy. *Med Decis Making* 2006; 26(4):347-359.
16. Hsung JM, Langlotz CP, Orel SG, Fox KR, Schnall MD, Schwartz JS. Cost-effectiveness of MR imaging and core-needle biopsy in the

- preoperative work-up of suspicious breast lesions. *Radiology* 1999;213(1):39–49.
17. Stout NK, Rosenberg MA, Trentham-Dietz A, Smith MA, Robinson SM, Fryback DG. Retrospective cost-effectiveness analysis of screening mammography. *J Natl Cancer Inst* 2006; 98(11):774–782.
 18. EuroQol—a new facility for the measurement of health-related quality of life. The EuroQol Group. *Health Policy* 1990;16(3):199–208.
 19. Torrance GW, Thomas WH, Sackett DL. A utility maximization model for evaluation of health care programs. *Health Serv Res* 1972;7(2):118–133.
 20. Torrance GW. Social preferences for health states: an empirical evaluation of three measurement techniques. *Socioecon Plann Sci* 1976;10(3):129–136.
 21. Faddy MJ, Gosden RG, Gougeon A, Richardson SJ, Nelson JF. Accelerated disappearance of ovarian follicles in mid-life: implications for forecasting menopause. *Hum Reprod* 1992;7(10):1342–1346.
 22. Swan JS, Sainfort F, Lawrence WF, Kuruchittham V, Kongnakorn T, Heisey DM. Process utility for imaging in cerebrovascular disease. *Acad Radiol* 2003;10(3):266–274.
 23. Stiggelbout AM, Eijkemans MJ, Kiebert GM, Kievit J, Leer JW, De Haes HJ. The 'utility' of the visual analog scale in medical decision making and technology assessment: is it an alternative to the time trade-off? *Int J Technol Assess Health Care* 1996;12(2):291–298.
 24. Loomes G. Disparities between health state measures: an explanation and some implications. York, England: University of York, 1988.
 25. Conover W. Practical nonparametric statistics. New York, NY: Wiley, 1999.
 26. Beinfeld MT, Bosch JL, Isaacson KB, Gazelle GS. Cost-effectiveness of uterine artery embolization and hysterectomy for uterine fibroids. *Radiology* 2004;230(1):207–213.
 27. Zowall H, Cairns JA, Brewer C, Lamping DL, Gedroyc WM, Regan L. Cost-effectiveness of magnetic resonance-guided focused ultrasound surgery for treatment of uterine fibroids. *BJOG* 2008;115(5):653–662.
 28. Brazier J, Roberts J, Deverill M. The estimation of a preference-based measure of health from the SF-36. *J Health Econ* 2002; 21(2):271–292.
 29. Beresniak A, Russell AS, Haraoui B, Bessette L, Bombardier C, Duru G. Advantages and limitations of utility assessment methods in rheumatoid arthritis. *J Rheumatol* 2007; 34(11):2193–2200.
 30. Duru G, Auray JP, Béresniak A, Lamure M, Paine A, Nicoloyannis N. Limitations of the methods used for calculating quality-adjusted life-year values. *Pharmacoeconomics* 2002; 20(7):463–473.
 31. Stiggelbout AM. Health state classification systems: how comparable are our cost-effectiveness ratios? *Med Decis Making* 2006; 26(3):223–225.
 32. Conner-Spady B, Suarez-Almazor ME. Variation in the estimation of quality-adjusted life-years by different preference-based instruments. *Med Care* 2003;41(7):791–801.
 33. Marra CA, Woolcott JC, Kopec JA, et al. A comparison of generic, indirect utility measures (the HUI2, HUI3, SF-6D, and the EQ-5D) and disease-specific instruments (the RAQoL and the HAQ) in rheumatoid arthritis. *Soc Sci Med* 2005;60(7):1571–1582.
 34. Gold MR, Siegel JE, Russell LB, Weinstein MC, eds. Cost-effectiveness in health and medicine: Oxford, England: Oxford University Press, 1996.
 35. Brazier J, Deverill M, Green C, Harper R, Booth A. A review of the use of health status measures in economic evaluation. *Health Technol Assess* 1999;3(9):i-iv, 1–164.
 36. O'Leary JF, Fairclough DL, Jankowski MK, Weeks JC. Comparison of time-tradeoff utilities and rating scale values of cancer patients and their relatives: evidence for a possible plateau relationship. *Med Decis Making* 1995;15(2):132–137.
 37. Spies JB, Coyne K, Guaou Guaou N, Boyle D, Skyrnarz-Murphy K, Gonzalves SM. The UFS-QOL, a new disease-specific symptom and health-related quality of life questionnaire for leiomyomata. *Obstet Gynecol* 2002;99(2): 290–300.
 38. Goodwin SC, Spies JB, Worthington-Kirsch R, et al. Uterine artery embolization for treatment of leiomyomata: long-term outcomes from the FIBROID Registry. *Obstet Gynecol* 2008;111(1):22–33.
 39. Swan JS, Miksad RA. Measuring the quality-of-life effects of diagnostic and screening tests. *J Am Coll Radiol* 2009;6(8):567–575.
 40. Yin D, Baum RA, Carpenter JP, Langlotz CP, Pentecost MJ. Cost-effectiveness of MR angiography in cases of limb-threatening peripheral vascular disease. *Radiology* 1995; 194(3):757–764.