Spring 5-27-1988

Watchful Waiting vs. Immediate Transurethral Prostatectomy for Symptomatic Prostatism

Albert G. Mulley Jr

Michael J. Barry

Floyd J. Fowler

John E. Wennberg
Dartmouth College, john.e.wennberg@dartmouth.edu

Watchful Waiting vs Immediate Transurethral Resection for Symptomatic Prostatism

The Importance of Patients' Preferences

Michael J. Barry, MD; Albert G. Mulley, Jr, MD, MPP; Floyd J. Fowler, PhD; John W. Wennberg, MD

The rate of resection for benign prostatic hypertrophy shows considerable variability among small geographic areas. To help inform the decision to recommend prostatectomy to men with prostatism without signs of chronic retention, we performed a decision analysis to compare the expected outcomes with immediate transurethral resection and watchful waiting. Data used in the model originated from the medical literature, Medicare claims data, and patient interview studies. In our base-case analysis for 70-year-old men, immediate surgery resulted in the loss of 1.01 months of life expectancy, but when adjustments were made for quality of life, immediate surgery was favored with a net utility benefit of 2.94 quality-adjusted life-months. However, the analysis was particularly sensitive to the degree of disutility attributed to the index symptoms of prostatism. We conclude that patient preferences should be the dominant factor in the decision whether to recommend prostatectomy.

(*JAMA* 1988;259:3010-3017)

WIDESPREAD variations in rates of surgical procedures among geographical areas have been interpreted as evidence for professional uncertainty concerning indications for these procedures.[1] Prostatectomy is one of the more common procedures for which such variation has been documented.[2-5]

Prostatectomy is performed both to prevent future morbidity and mortality and to reduce symptoms. Review of the literature and discussion with practicing urologists participating in the Maine Medical Assessment Program indicate little professional disagreement on the need to operate on patients with chronic urinary retention and large residual volumes or evidence of hydroureter or hydronephrosis, which poses a threat of urosepsis or renal failure. There is, however, considerable disagreement with the theory that prostatectomy extends life expectancy among patients without chronic retention by averting potentially fatal complications of prostate disease or by avoiding the need for surgery when the patient is older and at higher operative risk. This controversy has important implications for understanding and dealing with geographic variations in medical practice. If the only function of prostatectomy were to prevent outcomes such as urosepsis, renal failure, or death, which everyone agrees are necessary to avoid, a single "right" threshold for recommending prostatectomy might be based on clinical or urodynamic predictors of these complications. However, when the primary purpose of prostatectomy is to relieve symptoms and improve the quality of life, the decision to operate should depend heavily on the particular patient's relative preferences for different outcomes, including various levels of urologic symptoms and potential operative and nonoperative complications. Indications for prostatectomy cannot, therefore, be simply defined as appropriate or not; a "right" rate for prostatectomy in a community cannot be established without examining the individual decisions that contribute to the rate. We developed a decision-analysis model to understand more fully the preventive and quality-of-life indications for prostatectomy and to define the most important probabilities and utili-

See also pp 3018 and 3027.

From the General Internal Medicine Unit, Massachusetts General Hospital, and Harvard Medical School (Drs Barry and Mulley) and The Center for Survey Research, University of Massachusetts (Dr Fowler), Boston; and Dartmouth Medical School, Hanover, NH (Dr Wennberg). Dr Mulley is a Henry J. Kaiser Family Foundation Faculty Scholar in General Internal Medicine.

Reprint requests to the General Internal Medicine Unit, Massachusetts General Hospital, Bulfinch 1, Fruit St, Boston, MA 02114 (Dr Barry).

Table 1.—Basic States in Markov Model

State	Description
ASX	Spontaneous remission without surgery
ASXpTUR*	Remission after prostatectomy
ASXWET	Remission after prostatectomy except for mild incontinence
ASXIMP	Remission after prostatectomy except for impotence
STABLESX	Moderate symptomatic prostatism
STABpTUR*	Moderate urinary symptoms after prostatectomy
STABWET	Moderate urinary symptoms after prostatectomy and mild incontinence
STABIMP	Moderate urinary symptoms after prostatectomy and impotence
UTI	Serious urinary tract infection
INCONT	Severe incontinence
WORSpTUR	Severe urinary symptoms after prostatectomy
WORSWET	Severe urinary symptoms after prostatectomy and mild incontinence
WORSIMP	Severe urinary symptoms after prostatectomy and impotence
TURP†	Elective prostatectomy
UTITURP	Elective prostatectomy after infection
RETTURP	Emergent prostatectomy after retention
DEAD	Dead

*Because of the Markov assumption that transition probabilities depend only on present state regardless of previous states, the same symptom level must be represented by more than one state (eg, ASX and ASXpTUR), each of which has its own set of transition probabilities.

†The TURP state, with the same set of transition probabilities, applies to initial and repeated transurethral prostatectomy. Separate TURP states, not shown, are included in the model to reflect the assumption that men rendered impotent or incontinent by an initial operation who then require reoperation will not be cured of impotence or incontinence.

Table 2.—Relative Utility Estimates (With Ranges for Sensitivity Analysis) in Quality-Adjusted Months

State*	"Base-Case" Estimate	Sensitivity Analysis Low Estimate	Sensitivity Analysis High Estimate
ASXpTUR	1.00	. . .	. . .
ASX	0.97†	.90	.99
STABLESX, STABpTUR	0.89	.85	.97
ASXIMP, ASXWET	0.89	.50	.99
TURP, UTITURP	0.82	.50	.90
WORSpTUR	0.73	.40	.80
UTI, INCONT	0.50‡	0	.70
RETTURP	0.25	0	.50
DEAD	0.0	. . .	. . .

*See Table 1 for an explanation of the basic states in the Markov model.

†The utility of the ASX state relative to ASXpTUR was discounted slightly by Woodward et al because of the disutility of the apprehension of adverse events such as acute retention or infection or eventual surgery. In addition, men who spontaneously improve are likely to be putting up with more minor symptoms than men improved after prostatectomy.

‡The estimate by Woodward et al of 0.50 as the utility for urinary incontinence implies severe incontinence. Because the Maine Prostatectomy Study indicates that lesser degrees of incontinence are more common and are associated with decrements in mental health scores similar to those associated with postoperative impotence, we have added WET and IMP states reflecting these two postoperative conditions that can be combined (assuming independence) with states reflecting degree of irritative and obstructive symptoms (ie, ASX, STAB, WORS). We assumed that WET and IMP, states not addressed by Woodward and colleagues, have a utility equal to moderate prostatism (STABLESX).

ties contributing to the decision whether to recommend watchful waiting or immediate transurethral prostatic resection (TURP) for continent, sexually active men with prostatism.

METHODS

The prostatectomy decision depends on how the decision maker feels about outcomes that may or may not occur in the short term and during an extended time period. Furthermore, the patient may move from one health state to another repetitively over time. For example, symptoms may recur in the man whose operation was initially successful. When clinical decisions depend on transitions among health states during an extended time period, Markov models can be used to estimate prognosis in patients treated with different strategies.[6-10]

We used a Markov model to estimate the prognosis for continent, sexually active men with symptomatic prostatism who undergo *watchful waiting* (the "follow" strategy) or *immediate TURP* (the "operate" strategy). Transurethral prostatic resection was selected rather than open prostatectomy because it is the procedure performed most often in the United States. Men with postvoid residual volumes greater than 200 mL or creatinine values greater than 180 µmol/L (2 mg/dL), which may reflect obstructive uropathy, as well as men with evidence of prostate cancer, adynamic bladder, or other urologic disease are not considered. Seventeen basic states of prostatic health are incorporated in the model (Table 1). Men in each state may make transitions to other states with each cycle of one month's duration, a period that is sensitive to the duration of morbidity that may occur in some of the states (eg, serious urinary tract infection [UTI] or TURP). Transition probabilities were estimated from three sources: the published medical literature, the Medicare Part A Hospital Claims database for New England,[5] and survey data from the Maine Medical Assessment Program's Maine Prostatectomy Study.[11]

Time spent in each state is not of equal value; quality adjustment is necessary based on the relative values of the various states. A month in the "asymptomatic after prostatectomy" (ASXpTUR) state was assigned a value of 1.0 quality-adjusted month. A month in the "dead" (DEAD) state is assigned a value of 0.0. Utilities for other states were modified from Woodward and colleagues[12] and appear in Table 2.

We elected to use a starting age of 70 years, the median age for surgery in the Maine Prostatectomy Study, for a "base case" to estimate expected utility for each strategy. For purposes of the analysis, we assumed the men making the decision had "moderate" symptoms of prostatism as defined by the symptom index developed for the Maine Prostatectomy Study[11]; these men formed the largest symptom group in that study. Men can then make transitions to "mild" symptoms (ASX, ASXpTUR) or "severe" symptoms (WORSpTUR) or remain unchanged with moderate symptoms (STABLESX, STABpTUR). It is important to remember that these states are defined by an objective scale of symptom frequency; men in these states, because of differing personal utilities, might actually rate the same symptom level anywhere from not bothersome at all to intolerable. The model was run for 30 years (360 cycles), by which time more than 99.5% of all quality-adjusted months were accumulated; consideration of longer time frames did not alter the difference in prognosis between strategies.

Assumptions and Data

Several general assumptions were made: (1) Men followed up carefully without TURP will not develop irreversible azotemia due to obstructive uropathy, because those who develop evidence of chronic obstruction will be operated on. (2) All episodes of serious UTI and urinary retention in the "follow" cohort are attributable to benign prostatic hypertrophy, and the risks are reduced by a constant percentage after TURP. (3) Symptomatic outcomes of TURP are no different with immediate surgery or following a period of watchful waiting (ie, irreversible bladder decompensation does not result in a symptomatic "loss to cure" when surgery is delayed). (4) Transurethral prostatic resection does not prevent mortality from adenocarcinoma of the prostate. (5) Learning about incidental prostate cancer found at TURP does not reduce utility of subsequent life-months due to cancer fear. (6) Men who undergo

TURP with good results (transition to ASXpTUR or even ASXIMP or ASXWET) will undergo TURP again if symptoms deteriorate to the moderate range; however, men who do not improve after TURP will require further deterioration before submitting to reoperation, and men made much worse /(WORSpTUR or INCONT) will not submit to reoperation.

Transition Probabilities

Transition probabilities are the one-month probabilities that individuals will move from one state to another; all individuals who do not make a transition to a different state remain in the same state for another cycle. When an incidence density (D) is given in or calculated from the medical literature (events per person time), a monthly probability is calculated using the equation: monthly probability $= 1 - e^{D}$, where D is in events per person-month.[13]

Monthly transition probabilities are summarized in Tables 3 and 4; the basis for these estimates is described in the Appendix.

Calculations were performed using "SMLTREE," a decision-analysis program for the IBM microcomputer that features an ability to incorporate Markov processes.[14]

Future life-months were not discounted in the base case. However, in a sensitivity analysis, we examined the effects of different discount rates (d) by dividing the utility of future life-months by $(1+d)^t$, where t is the elapsed time in years from the starting age.[15]

Table 3.—Summary of Transition Probabilities for One-Month Cycles of Markov Model*

	STABLESX	ASX	TURP	UTI	UTITURP	RETTURP	DEAD
STABLESX	$1-\Sigma$	.024 (1-12) .0 (13-360)	.0049	.00033	0	.00033	+†
ASX	.004	$1-\Sigma$	0	.00033	0	.00033	+
UTI	0	0	0	0	.97	0	.03
	STABpTUR‡	**ASXpTUR‡**	**WORSpTUR**	**UTI**	**RETTURP**	**INCONT**	**DEAD**
TURP (UTITURP, RETTURP)	.15§	$1-\Sigma$	.055‡	0	.015	.005§	+ +
ASXpTUR (ASXIMP, ASXWET)	.0018‖	$1-\Sigma$	0	.00007	.00007	0	+
STABpTUR (STABIMP, STABWET)	$1-\Sigma$	0	.0018‖	.00007	.00007	0	+
WORSpTUR (WORSIMP, WORSWET)	$1-\Sigma$	0	0	0	0	0	+
INCONT	$1-\Sigma$	0	0	0	0	0	+

*See Table 1 for an explanation of the basic states in the Markov model.

† + indicates age-dependent death rates taken from gender-specific life tables for US population (see Appendix); and + +, age-dependent operative mortality estimated from Medicare claims data (see Table 4).

‡Symptom levels reflect irritative and obstructive symptoms with or without postoperative impotence or mild incontinence (see Appendix).

§Actually, these probabilities are applied to survivors who do not undergo immediate reoperation; for example, p(TURP—>STABpTUR) = 0.15(1 – pDEATH – pRETTURP). In addition, for each of these symptomatic transitions men may develop minor incontinence (.04) or impotence (.05).

‖Patients who make this transition are assumed to go on to repeated TURP.

RESULTS

Base Case: The 70-Year-Old Man

In the base-case analysis, using probabilities appropriate for the 70-year-old sexually active continent man with "moderate" symptoms but without chronic obstruction, the expected quality-adjusted utility for the "follow" (watchful waiting) strategy is 119.97 quality-adjusted life-months (QALMs). The expected utility for the "operate" (immediate surgery) strategy is 122.91 QALMs; surgery provides a net expected benefit of 2.94 QALMs. While the 70-year-old choosing surgery faces an expected loss of 1.07 QALMs due to operative risk, he would gain an expected 0.06 QALMs due to prevention of urosepsis and 3.95 QALMs due to improvement in symptoms of prostatism.

When no quality adjustments are made, the model predicts a net loss of 1.01 months of life expectancy for those who undergo immediate operation. Therefore, for patients without chronic

Table 4.—Operative Mortality as a Function of Age*

	Predicted Operative Mortality	
Age, y	**12 wk**	**6 wk**
65	.0097	.0038
70	.0155	.0065
75	.0240	.0113
80	.0391	.0196
85	.0620	.0340

*Estimated from Medicare Part A Hospital Claims data for 16446 men who underwent transurethral prostatectomy for benign disease in New England in 1983 through 1985, from a logistic regression model and using the log odds of death during 12 or six weeks following elective prostatectomy as the dependent variable and age as the independent variable.

obstruction, the decision to operate requires a trade-off between expected quality of life and quantity of life.

Because the man who is already impotent cannot lose utility due to postoperative sexual dysfunction, the net expected benefit of the operate strategy will be higher, ie, 3.50 QALMs. The man who opts for watchful waiting may not permanently forgo surgery. The model indicates that 42% of 70-year-old men who initially defer surgery would eventually undergo TURP for symptom deterioration, acute retention, or serious UTI. The model also indicates that the 70-year-old man opting for early surgery may face the same decision again; the model predicts a cumulative probability of 21% for at least one repeated operation. Table 5 lists the cumulative probability of initial TURP in the "follow" strategy and of reoperation in the "operate" strategy during the 30 years following the initial decision.

The time-dependence of the benefit of

Table 5.—Probability of Initial Operation in 'Follow' and Reoperation in 'Operate' Over Time

Elapsed Time, y	"Follow" Probability of TURP*	"Operate" Probability of Repeated TURP
1	.05	.03
5	.21	.10
10	.33	.16
20	.40	.21
30	.42	.21

*TURP indicates elective prostatectomy.

surgery can be analyzed by examining accrued quality-adjusted months at different numbers of cycles. At one year, the net benefit of "operate" is only 0.40 QALMs; at five years, 1.59 QALMs; and at ten years, 2.40 QALMs.

Sensitivity Analyses

One-way sensitivity analyses for the probabilities and utilities in the model for the base-case starting age of 70 years are found in Tables 6 and 7. Interestingly, the analysis was insensitive to variation in the assumptions regarding the "preventive" nature of TURP—that is, the differential risk of retention and infection between the two strategies. To some degree, this finding reflects our structural assumption that, although the utility of an episode of retention or infection was low, the surgical outcomes following such an event were similar. However, even if we doubled the probability of a worse symptomatic outcome in UTITURP and RETTURP, the net benefit of surgery increased to only 2.98 QALMs. The analysis was also quite insensitive to discount rate.

Table 6.—One-Way Sensitivity Analyses—Probabilities

Variable	Value	Benefit of Surgery at Age 70 y, QALMs*
1. Probability of spontaneous remission (mo 1-12)	.000 .024† .048	4.35 2.94 1.86
2. Probability of symptomatic deterioration after spontaneous remission	.0 .004† .008	2.38 2.94 3.28
3. Probability of UTI	.00000 .00033† .00100	2.95 2.94 2.93
4. Probability of death from UTI	.00 .03† .10	2.87 2.94 3.10
5. Relative risk ratio of acute retention and UTI after TURP	1.00 0.20† 0.00	2.68 2.94 3.01
6. Probability of operative mortality (times baseline)	0.5× 1.0×† 1.5× 2.0× 2.5× 3.0×	3.61 2.94 2.28 1.61 0.95 0.29
7. Probability of acute retention	.000 .00033† .0010	3.00 2.94 2.82
8. Relative risk of operative mortality after retention	1.0† 2.0 3.0	2.94 2.98 3.03
9. Relative risk of operative mortality after infection	1.0† 2.0 3.0	2.94 2.98 3.03
10. Probability of severe incontinence after TURP	.000 .005† .010	3.20 2.94 2.69
11. Probability of severe symptoms after TURP	.01 .055† .11	4.16 2.94 1.47
12. Probability of moderate symptoms after TURP	.05 .15† .30	3.91 2.94 1.50
13. Probability of early reoperation	.005 .015† .030	2.96 2.94 2.92
14. Probability of late reoperation for recurrence or stricture	.0 .0018† .0040	2.85 2.94 3.08
15. Discount rate, %	0† 5 10	2.94 2.27 1.85
16. Probability of postoperative impotence	.00 .05† .10	3.50 2.94 2.42
17. Probability of postoperative mild incontinence (wetness)	.00 .04† .08	3.38 2.94 2.55

*QALMs indicates quality-adjusted life-months; UTI, serious urinary tract infection; and TURP, elective prostatectomy.
†Baseline values.

The variables to which the model is most sensitive are the operative mortality rate, the utility of the STABLESX state (both STABLESX and STABpTUR), and the utility of the ASXIMP state (Fig 1). Figure 1, Top, demonstrates the effect of varying the operative mortality (at all ages) from half the baseline assumption to three times the baseline assumption. This sensitivity analysis is particularly important both because the true *attributable* mortality of surgery is unclear and because operative mortality will vary depending on both patient factors (eg, comorbidity) and surgeon/hospital factors (eg, skill or quality). At threefold operative mortality, a threshold favoring watchful waiting is approached but not reached. When we used the logistic model for operative mortality based on deaths at six weeks (Table 4), the net benefit of surgery was 3.74 QALMs, approximately equivalent to halving the baseline rate (Table 6). The relationship of uSTABLSX and expected quality-adjusted survival of the two cohorts is shown in Fig 1, Center. When the utility of moderate prostatism, relative to death (0.0) and the postoperative asymptomatic state (1.0), is greater than 0.945, watchful waiting becomes the preferred strategy. The impact of varying degrees of disutility associated with loss of sexual function is seen in Fig 1, Bottom. As the utility of ASXIMP drops to 0.5, the utilities of the strategies approach but do not reach a threshold.

Figure 2 illustrates the interaction of uSTABLESX, operative mortality, and the utility assignment for the state of being impotent without urinary symptoms (uASXIMP). The upper threshold line, with no disutility assigned to impotence (uASXIMP=1.0), is quantitatively the same as for sexually inactive men who cannot lose utility from impotence. A man for whom the state of impotence holds considerable disutility (uASXIMP=0.75 or even 0.50) should be willing to put up with relatively more bothersome degrees of symptomatic prostatism rather than elect surgery. At high levels of operative mortality, the absolute thresholds for uSTABLESX would become relatively low compared with the thresholds at low operative mortality. Again, operative mortality would depend on comorbidity and the surgeon and hospital selected.

In Fig 3, the net benefit of "operate" is shown for a spectrum of starting ages. Without utility adjustments, the model favors "follow" across the age range, with a net benefit of 0.37 life-months at age 60 to a net benefit of 2.36 life-months at age 85. When quality adjustments are made, however, the net benefit decreases across this range from 4.68 QALMs at age 60 to -0.11 QALMs (a slight benefit favoring "follow") at age 85. As one gets older, the initial operative toll is steeper, and there are fewer years of life left to enjoy the symptomatic benefits of surgery.

Structural Sensitivity Analyses

Several analyses were done to challenge the structural assumptions implicit in the Markov model. We had assumed watchful waiting would include regular physician visits and periodic determination of renal function and residual volume to prevent deterioration in renal function due to obstructive uropathy. But what if some men are lost to follow-up, or waiting is not as "watchful" as anticipated? To evaluate the importance of this question for the consequences of the watchful waiting strategy, we assumed that after five years, the rate of development of end-stage renal disease among men with untreated symptomatic prostatism would be equal to the acute retention rate (.00033 per month) and would be reduced 80% by TURP. Assuming a monthly excess probability of death due to end-stage renal disease of .0211 and

Table 7.—One-Way Sensitivity Analyses—Utilities

Variable	Value	Benefit of Surgery at Age 70 y, QALMs*
1. Quality of life for spontaneous remission from moderate prostatism	0.90 0.97† 0.99	4.43 2.94 2.51
2. Quality of life for moderate prostatism	0.85 0.89† 0.93 0.97	5.22 2.94 0.66 −1.61
3. Quality of life for transurethral resection	0.90 0.82† 0.50	3.01 2.94 2.69
4. Quality of life for serious urinary tract infection	0.7 0.5† 0	2.93 2.94 2.96
5. Quality of life for severe incontinence	0.7 0.5† 0	3.05 2.94 2.68
6. Quality of life for severe urinary symptoms	0.80 0.73† 0.40	3.34 2.94 1.06
7. Quality of life for retention and transurethral resection	0.50 0.25† 0	2.94 2.94 2.95
8. Quality of life for postoperative impotence without urinary symptoms	0.50 0.70 0.89† 1.00	1.03 2.01 2.94 3.50
9. Quality of life for mild incontinence (wetness) without other urinary symptoms	0.50 0.89† 0.99	1.40 2.94 3.35

*QALMs indicates quality-adjusted life-months.
†Baseline values.

the utility of a month of undergoing dialysis to be 0.80,[16] the net benefit favoring surgery increases only slightly to 3.48 QALMs. Without quality adjustments, watchful waiting became preferable, as was the situation in the base-case analysis, with a net benefit of 0.46 QALMs. We doubt that the risk of progression to end-stage renal disease is as great as the risk of acute retention.

The data from the Maine Prostatectomy Study do not support worse symptomatic outcomes for individuals with severe as opposed to moderate symptoms.[11] However, an academic concern might be raised that long-standing obstruction may cause bladder decompensation (a "cystomyopathy") that could result in poorer symptomatic outcomes with delayed compared with immediate surgery. We had assumed the same response to surgery in "operate" and "follow." If, however, the chances of both worse symptoms and unimproved symptoms after operation were increased by 25% in "follow," the net benefit of "operate" would increase slightly to 3.25 QALMs. If worse or unchanged postoperative symptomatic outcomes were 50% more likely after watchful waiting, the net benefit of "operate" would become 3.56 QALMs.

COMMENT

Our "base-case" analysis for sexually active, continent 70-year-old men with moderate symptomatic prostatism demonstrates a small improvement in prognosis of about three QALMs if immediate transurethral resection is chosen over watchful waiting. Although more life-months are lost from operative deaths in the "operate" strategy, the net benefit results from an improvement in the average mix of symptoms for the survivors. Prevention of morbidity from UTI or acute retention was a minimal factor, as was prevention of mortality due to urosepsis. Again, it must be emphasized that our model applies to men without elevated serum creatinine levels or large postvoid residuals, stigmata of chronic retention. We also assumed waiting was truly watchful, so that men would not develop progressive undetected renal injury due to obstructive uropathy.

When single variables were analyzed using sensitivity analysis, the results were sensitive to the utility assignment for the STABLESX state, the state that describes the level of symptoms of the men who face the decision. The operative mortality rate and the utility assignment for lost sexual function also had appreciable influence but did not in isolation change the conclusion that "operate" is the preferred strategy. The starting age of the cohort also influenced the result of the model; older individuals are at higher surgical risk and have a shorter life span during which to reap the benefits of improved urinary symptoms.

Operative mortality was the single *probability* that most influenced the model. The risk of transurethral surgery is small and age dependent. The true *attributable* risk of surgery will probably never be known; a randomized trial of watchful waiting vs immediate surgery could not define an early difference in mortality with a narrow confidence interval without a prohibitively large sample size, given the low outcome rate (Table 4). If individuals referred for surgery have average comorbidity, comparable with that of the populations in the Social Security life tables, then the difference in observed and expected 12-week mortalities would be a good estimate for attributable risk. However, if healthier patients undergo operation and sicker patients are watched, as seems reasonable, this calculation would underestimate attributable mortality. Operative mortality is also influenced by patient factors and surgeon/hospital factors. Patients with comorbid conditions would be expected to have a higher operative mortality rate as well as a shorter expected life span, which would tend to favor watchful waiting.

The most important result leading to a better understanding of variation in prostatectomy rates is the potent influence of the utility assignments of STABLESX and ASXIMP. The utility assignments made by Woodward and colleagues were not based on preferences elicited from patients. Individual patients would likely assign widely different utilities to similar symptom states, depending on the degree to which these functional states interfered with their lives and their own psychological makeup. The Maine Prostatectomy Study shows that patients with similar symptoms can differ markedly in how much their symptoms bother them.[11] Documented variability in prostatectomy rates in small geographic areas raises questions about whose utilities influence decisions to operate or not. Differences in preferences or attitudes toward risk among the relatively small number of clinicians who perform the procedure may be a more likely explanation for practice variation than systematic differences among the larger number of patients who reside in different areas. Differences in preference among referring physicians might also affect utilization rates, as has been documented for other procedures.[17]

Were the utility assignments taken from Woodward and colleagues[12] fair estimates for men with moderate symptomatic prostatism? One interpretation

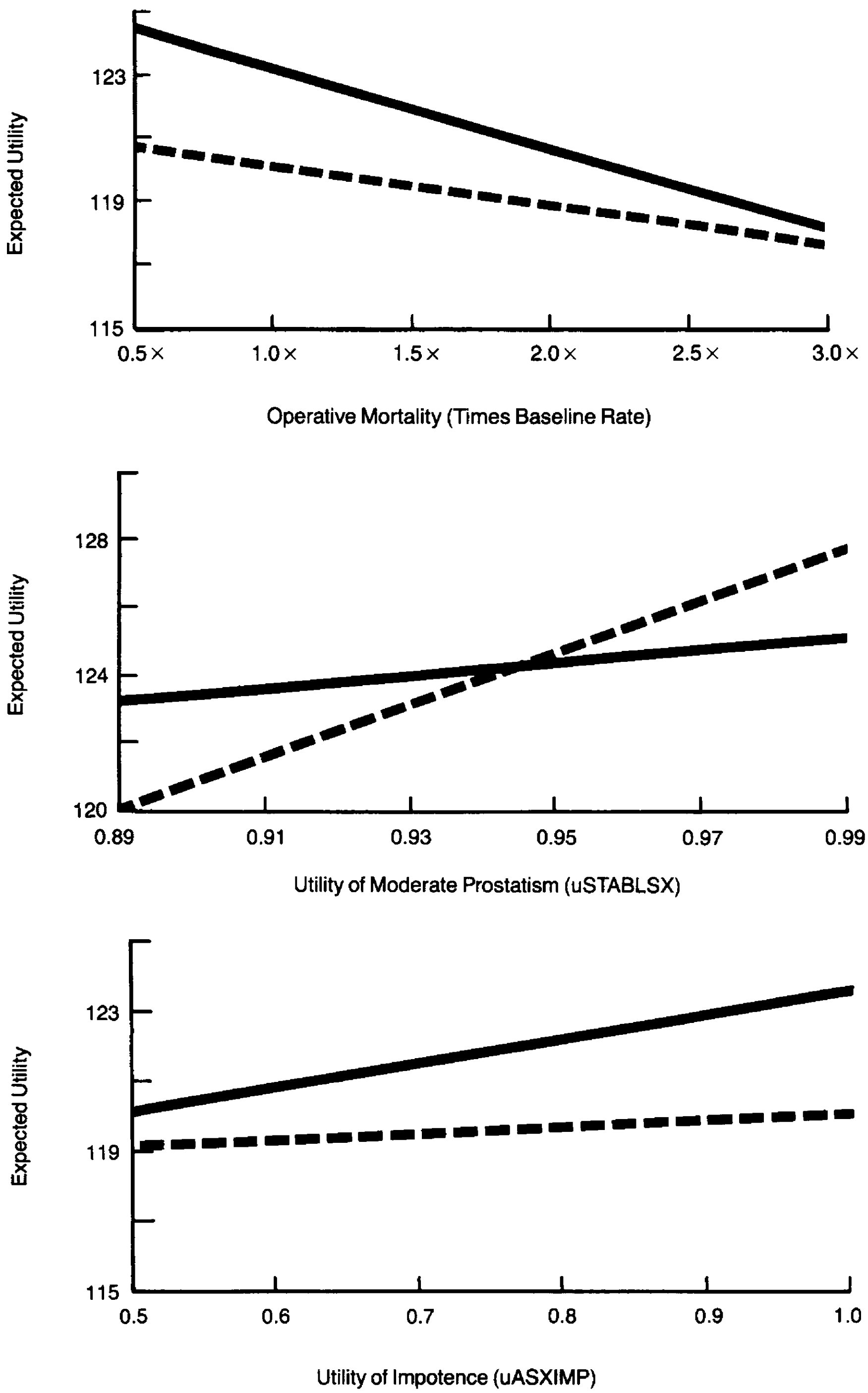

Fig 1.—Expected utility of "operate" (solid line) and "follow" (dashed line) strategies in quality-adjusted life-months as they vary with three variables to which model is most sensitive: Top, operative mortality rate; Center, utility assignment for state of moderate symptomatic prostatism (uSTABLSX); and Bottom, utility assignment for state of impotence without other urinary symptoms (uASXIMP).

of our baseline utility of 0.89 is that patients in this group would be willing to risk up to an 11% chance of death to be relieved of their symptoms. Given that men in Maine with moderate symptoms, despite impressive symptom improvement, had only small, statistically insignificant improvements in their activity, mental health, and general health indices,[11] this utility assignment may well be too low for most men. Methods for accurately assessing utilities for health states relevant to the prostatectomy decision are an area of current investigation.[18,19]

An important implication of the dominance of these utility factors is that there can be no truly definitive list of indications that can be promulgated and readily reviewed retrospectively to decide on the appropriateness of a surgical (or nonsurgical) recommendation. Patients must be asked about their preferences for outcomes, and these will differ for patients with similar medical histories, findings from physical examinations and laboratory studies, and symptom levels. For procedures where the "preventive" component dominates thinking, such as colectomy for cancer of the bowel, a uniform threshold for surgery based on objective criteria that can be reviewed retrospectively seems feasible. However, when operations that carry risks are undertaken primarily to improve the quality of life, the threshold should appropriately vary from patient to patient, according to the strength of their feelings about their symptoms and their attitudes toward risk. Further study of patient utilities for functional outcomes following prostatectomy should help to preserve patient autonomy despite the great current pressures to streamline and standardize medical practice.[20]

How "generalizable" is our analysis to all men undergoing prostatectomy? The majority of men undergo prostatectomy for symptomatic relief, and we have directly modeled the outcomes of immediate surgery and watchful waiting for the group with moderate symptoms. Since the distribution of symptom states after surgery seems independent of the initial symptom state,[11] the modeling of the "operate" strategy should be accurate for individuals with mild or severe symptoms, once appropriate utility adjustments are made. We doubt that our results apply to men with evidence of chronic urinary retention, defined by postvoid residual urine volumes greater than 200 mL, evidence of hydroureter or hydronephrosis, or serum creatinine levels higher than 180 μmol/L (2 mg/dL). For these men, the "preventive" argument is stronger. However, another large group of men who undergo prostatectomy are those who have had an episode of acute urinary retention. Some experts have considered acute retention an absolute indication for prostatectomy,[21] but in actual practice patients with episodes of acute obstruction are commonly followed up rather than operated on. The inability of prostate size, symptom severity, or

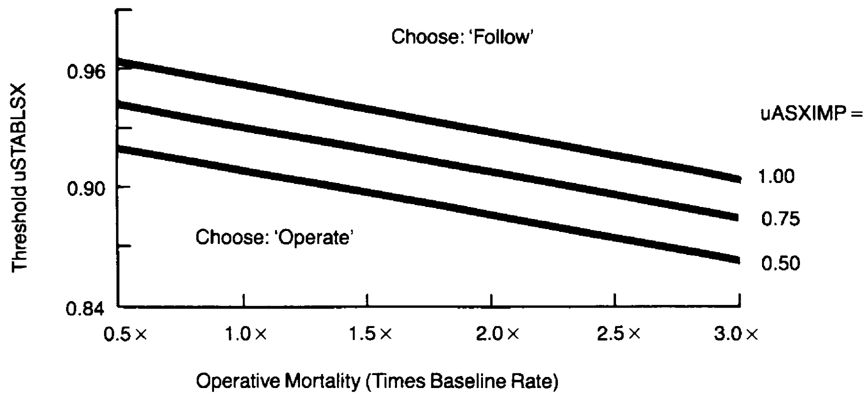

Fig 2.—Threshold utility of state of moderate symptomatic prostatism (uSTABLSX) as it varies with operative mortality and with utility assignment for state of impotence without other urinary symptoms (uASXIMP).

Fig 3.—Net benefit of "operate" defined as expected quality-adjusted life-months (QALMs) of "operate" strategy *minus* QALMs of "follow" strategy as it varies with patient age.

urodynamic measurements to predict acute retention has suggested to some authors that a sudden event such as prostatic infarction may best explain acute retention.[22,23] If this mechanism is common, then men who are able to void successfully after a period of catheter drainage, after resolution of postinfarct edema, would seem to be eligible for a trial of watchful waiting, if there were no signs of chronic retention. The same would likely be true for men whose episodes of acute retention were precipitated by bed rest, diuresis, or the use of anticholinergic medications.

Our decision model has allowed us to pull together data from many sources to try to best inform physicians' and patients' decisions about prostatectomy. The Medicare Part A Hospital Claims database has been particularly helpful in estimating surgical risks for a very broad population of men undergoing TURP. Moreover, the Maine Prostatectomy Study has provided key information on the functional outcomes of surgery not available in the urologic literature. There are still many gaps in our knowledge, however. The natural history of untreated prostatism needs closer definition. Although generous variation in our natural history assumptions did not substantially influence our results in isolation, it is possible that a systematically better or worse natural history involving many variables might be important for at least some individuals whose age, operative risk, or utilities make the decision more a "toss-up." We await with interest the results of an ongoing Veteran's Administration randomized-control trial comparing the results of immediate surgery vs watchful waiting, especially since some men with acute retention will be included. In the meantime, however, there is much to do in developing methods that will allow clearer communication of currently available information to patients who face the prostatectomy decision. The informed patient who can make quality-of-life decisions based on his own preferences and attitudes toward risk may be our best safeguard against the concerns about cost and quality raised by variations in medical practices.

APPENDIX: ESTIMATION OF TRANSITION PROBABILITIES

STABLESX

We calculated the probability of a spontaneous symptomatic remission by assuming that 20% of patients not undergoing operation improve[24] and all the improvement occurs in the first year.[22] Therefore, the monthly probability of remission is .024 for cycles 1 through 12 and .0 thereafter. This assumption is supported by the short-term remission rates deserved in the placebo arms of drug studies.[25-28] The monthly probability of symptom deterioration requiring surgery was .0049 in Ball's natural history series; of acute retention, .00033.[24] There is no information on the risk of serious UTI; we assume it is the same as the acute retention rate. The probability of death depends on age (a function of the number of elapsed Markov cycles) and is taken from gender-specific US life tables built into the model.[29] We use the same monthly probability of death in all nonsurgical states except UTI.

ASX

After spontaneous remission of symptoms, deterioration can occur; the remissions in the series of Ball et al[24] and Birkoff et al[22] seemed durable, but follow-up was only three to five years. In the series of Craigen et al,[30] ten operations were performed in 2496 person-months beyond three years of follow-up; although these individuals may not have been asymptomatic, we use these data to calculate a "worst case" relapse rate of 0.004 per month. We also conservatively assume that the risk of retention and infection does not decrease with symptomatic remission, which is generally not accompanied by "urodynamic" remission.[26,28,31]

UTI

The risk of death from serious UTI is estimated to be .03[32]; survivors go on to elective TURP (UTITURP).

TURP (UTITURP, RETTURP)

Operative mortality is age dependent and may be underestimated when inhospital or 30-day mortality is examined.[5,33] Our operative mortality estimates were derived from Medicare claims data (Table 4); the logistic function itself was built into the model. The 12-week data were used in the base case. We assumed the probability of revision TURP soon after operation would be .015.[34,35] For survivors not requiring reoperation, probabilities for symptom transitions from the Maine Prostatectomy Study were as follows: 6% worse, which we broke down to a .055 probability of transition to WORSpTUR and a .005 probability of severe incontinence[34,35]; 18% the same (STABpTUR); and 77% better (ASXpTUR). In the base case, transitions were the same for surgery following treated UTI or acute retention.

For men who go to each of the three symptom states (ASXpTUR, STABpTUR, WORSpTUR), the probability of also having minor wetness or impotence is .04 and .05, respectively. These figures represent the probability that men continent or sexually active at the outset of the Maine Prostatectomy Study would report wetness or inability to get an erection at 3, 6, and 12 months after surgery.

ASXpTUR (ASXIMP, ASXWET)

We calculate a monthly probability of revision of .0018 (for both stricture requiring more than in-office dilatation and the occurrence of benign prostatic hypertrophy).[36] This estimate yields cumulative reoperation frequencies (Table 5) similar to those documented in reviewing Medicare claims data.[5] We assume that surgery reduces the risk of infection and retention by 80% to .00007 per month.

STABpTUR (STABIMP, STABWET)

We assume revision and complication probabilities in this state are the same as in ASXpTUR.

WORSpTUR (WORSIMP, WORSWET), INCONT, DEAD

No transitions are allowed from these first four states except with death; the dead state is an "absorbing" state with no transitions.

This study was supported by grants from the John A. Hartford Foundation Inc and the National Center for Health Services Research.

References

1. Wennberg JE, Barnes BA, Zubkoff M: Professional uncertainty and the problem of supplier-induced demand. *Soc Sci Med* 1982;16:811-824.
2. Barnes BA, O'Brien E, Comstock C, et al: Report on variation in rates of utilization of surgical services in the Commonwealth of Massachusetts. *JAMA* 1985;254:371-375.
3. Wennberg JE, Gittelsohn A: Health care delivery in Maine: I. Patterns of use of common surgical procedures. *J Maine Med Assoc* 1975;66:123-130, 149.
4. McPherson K, Wennberg JE, Hovind OB, et al: Small-area variation in the use of common surgical procedures: An international comparison of New England, England, and Norway. *N Engl J Med* 1982;307:1310-1314.
5. Wennberg JE, Roos N, Sola L, et al: Use of claims data systems to evaluate health care outcomes: Mortality and reoperation following prostatectomy. *JAMA* 1987;257:933-936.
6. Beck JR, Pauker SG: The Markov process in medical prognosis. *Med Decis Making* 1983;3:419-458.
7. Ransohoff DF, Gracie WA, Wolfenson LB, et al: Prophylactic cholecystectomy or expectant management for silent gallstones: A decision analysis to assess survival. *Ann Intern Med* 1983;99:199-204.
8. Sonnenberg A: Endoscopic screening for gastric stump cancer—would it be beneficial? A hypothetical cohort study. *Gastroenterology* 1984;87:899-895.
9. Hillner BE, Hollenberg JP, Pauker SG: Postmenopausal estrogens in the prevention of osteoporosis: Benefit virtually without risk if cardiovascular effects are considered. *Am J Med* 1986;80:1115-1127.
10. Matchar DB, Pauker SG: Endarterectomy in carotid artery disease: A decision analysis. *JAMA* 1987;258:793-798.
11. Fowler FJ, Wennberg JE, Timothy RP, et al: Symptom status and quality of life following prostatectomy. *JAMA* 1988;259:3018-3022.
12. Woodward R, Boyarsky S, Barnett H: Discounting surgical benefits: Enucleation vs resection of the prostate. *J Med Syst* 1983;7:481-493.
13. Kleinbaum DG, Kupper LL, Morgenstern H: *Epidemiology Research.* London, Life Learning Publications, 1982, pp 106-111.
14. Hollenberg JP: Markov cycle trees: A new representation for complex Markov processes, abstracted. *Med Decis Making* 1984;4:529A.
15. Weinstein MC, Feinberg HV: *Clinical Decision Analysis.* Philadelphia, WB Saunders Co, 1980.
16. Dunn VH, Pauker SG: An ambiguous renal cyst in a patient with prior nephrectomy: What to do when there is only one more to lose. *Med Decis Making* 1986;6:49-62.
17. Bloor MJ, Venters GA, Samphier ML: Geographic variations in the incidence of operations on the tonsils and adenoids: An epidemiologic and sociologic investigation. *J Laryngol Otol* 1978;92:791-801.
18. Krumins PE, Fihn SD, Kent DL: Symptom severity and patients' values in the decision to perform a transurethral resection of the prostate. *Med Decis Making* 1988;8:1-18.
19. Wennberg JE, Mulley AG, Hanley D, et al: An assessment of prostatectomy for benign urinary tract obstruction: Geographic variations and the evaluation of medical care outcomes. *JAMA* 1988;259:3027-3030.
20. McNeil BJ, Pauker SG, Sox HC, et al: On the elicitation of preferences for alternative therapies. *N Engl J Med* 1982;306:1259-1262.
21. Muller A: When is prostatectomy indicated? *Br J Surg* 1965;52:744-745.
22. Birkoff JD, Weiderhorn AR, Hamilton ML, et al: Natural history of benign prostatic hypertrophy and acute urinary retention. *Urology* 1976;7:48-52.
23. Spiro LH, Labay G, Orkin LA: Prostatic infarction: Its role in acute urinary retention. *Urology* 1974;3:345-347.
24. Ball AJ, Feneley RC, Abrams PH: The natural history of untreated 'prostatism.' *Br J Urol* 1981;53:613-616.
25. Resnick M, Jackson JE, Watts LE, et al: Assessment of the antihypercholesterolemic drug, probucol, in benign prostatic hyperplasia. *J Urol* 1983;129:206-209.
26. Hedlund H, Andersson KE, Ek A: Effects of prazocin in patients with benign prostatic obstruction. *J Urol* 1983;130:275-278.
27. Castro JE, Griffiths JH, Edwards DE: A double-blind, controlled clinical trial of spironolactone for benign prostatic hypertrophy. *Br J Surg* 1971;58:485-489.
28. Geller J, Nelson CG, Albert JD, et al: Effect of megestrol on uroflow rates in patients with benign prostatic hypertrophy. *Urology* 1979;14:467-474.
29. Faber JF, Wade AH: *Life Tables for the United States: 1900-2050* (actuarial study No. 89). Dept of Health and Human Services, Social Security Administration, Office of the Actuary (SSA publication 11-11536), 1983.
30. Craigen AA, Hickling JB, Saunders CR, et al: Natural history of prostatic obstruction. *J R Coll Gen Pract* 1969;18:226-232.
31. Jensen KM, Madsen PO: Candicidin treatment of prostatism: A prospective double-blind placebo-controlled study. *Urol Res* 1983;11:7-10.
32. Gleckman RA: Community-acquired urosepsis, in Gleckman RA, Gantz NM (eds): *Infections in the Elderly.* Boston, Little Brown & Co Inc, 1983, pp 265-281.
33. Sach R, Marshall VR: Prostatectomy: Its safety in an Australian teaching hospital. *Br J Surg* 1977;64:210-214.
34. Melchior J, Valk WL, Foret JD, et al: Transurethral prostatectomy: Computerized analysis of 2223 consecutive cases. *J Urol* 1974;112:634-642.
35. Chilton CP, Morgan RJ, England HR, et al: A critical evaluation of the results of transurethral resection of the prostate. *Br J Urol* 1978;50:542-546.
36. Holtgrewe HL, Valk WL: Late results of transurethral prostatectomy. *J Urol* 1964;92:51-55.