Cost-Utility Analysis of Cataract Surgery in the Second Eye

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Objective: To perform a reference case cost-utility analysis of second-eye cataract surgery by using the current literature on cataract outcomes and complications.

Design: Computer-based econometric modeling.

Methods: Visual acuity data of patients treated and observed over a 4-month postoperative period were obtained from the U.S. National Cataract Patient Outcomes Research Team report. The results from this prospective study were combined with those of other studies that investigated the complication rates of cataract surgery to complete the cohort of patients and outcomes. These synthesized data were incorporated with time trade-off utility values, which accounted for prior successful cataract surgery in the fellow eye. Cost-utility determinations were made with decision analysis, and present value modeling was used to account for the time value of money and health state consequences.

Main Outcome Measures: The number of quality-adjusted life-years (QALYs) gained was calculated for the study group undergoing second-eye cataract surgery, assuming that the postoperative vision in the second eye was equivalent to the vision in the first eye after surgery (20/27). This was divided into the cost of the procedure to find the number of year 2001 nominal U.S. dollars spent per QALY gained.

Results: Second-eye cataract surgery, as compared with unilateral pseudophakia, resulted in a mean gain of 1.31 undiscounted QALYs per patient treated. A 3% annual discount rate, dependent on the duration of benefit, was used, yielding 0.92 discounted QALYs gained over a 12-year life expectancy. The mean discounted cost of treatment for each patient totaled $2509. The cost divided by the QALYs gained (benefit) resulted in $2727 per QALY gained for this procedure. Sensitivity analysis varying costs and utility values revealed a range from $2045 to $3649 per QALY gained.

Conclusions: Second-eye cataract surgery is an extremely cost-effective procedure when compared with other interventions across medical specialties. The cost-effectiveness of second-eye surgery diminishes only slightly from the $2023 per QALY gained from first-eye cataract surgery. This suggests that patients with good vision in one eye and visual loss from cataract in the fellow eye derive substantial benefit from cataract extraction. *Ophthalmology 2003;110:2310–2317 © 2003 by the American Academy of Ophthalmology.*

Cataract surgery in the setting of unilateral pseudophakia, accounting for over $1 billion of the Medicare budget,[1] has undergone continued scrutiny by insurers and certain subsets of the health care community. The rapid expansion in the number of cataract surgeries due to better anesthesia, quicker recovery times, and fewer complications over the past two decades has made cataract surgery the most utilized procedure by Medicare beneficiaries.[2] The question that has been asked over the past decade is whether the benefit of second-eye cataract extraction for the patient justifies the allocation of substantial private and governmental resources. As late as 1993, it was noted by a governmental agency that there were no publications addressing the benefits of second-eye cataract surgery.[3] Many researchers since this time have devoted important work to assessing the visual acuity change, functional change, and overall quality of life change associated with this procedure.

The evolution of outcomes research related to initial cataract extraction has enlightened the medical community to the benefits of cataract surgery. Visual acuity data of modern cataract surgery have consistently shown a mean postoperative Snellen visual acuity of approximately 20/25.[4–6] Along with the objective outcomes routinely measured by the ophthalmologist, researchers have improved techniques of measuring the benefit of cataract extraction. A

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widely accepted tool for the assessment of functional benefit after cataract extraction has been the visual functioning index, VF-14.[7,8] The critical sight-dependent activities measured by the VF-14 have shown improvement after initial cataract surgery. Other studies have used different or specific measures to assess the benefit of initial cataract extraction.[9–12] Most recently, evaluation of the cost-effectiveness of initial cataract surgery by using utility value analysis has been described as extremely cost-effective when compared with other interventions across medical specialties.[13]

With cost-containment pressures arising from the projected $2.17 trillion health care bill by 2008 in the United States,[14] many investigators have recently compared the benefit after first-eye cataract extraction vs. the benefit after second-eye cataract extraction. Assessment of binocularity and remaining visual symptoms with unilateral pseudophakia has been the basis in many of these studies for concluding that second-eye cataract surgery is warranted.[15–21] Other studies, which include assessment with the VF-14, Activities of Daily Living Scale, and the Sickness Impact Profile, have focused on the difference in function and quality of life between unilateral and bilateral pseudophakia.[2,21–24] Additional studies have shown a relationship between self-reported difficulties with activities of daily living and multiple measures of vision, including stereoacuity, which is related to higher Activities of Daily Living Scale scores.[25,26] Although studies have uniformly shown improvement in specific outcome measures after second-eye cataract surgery,[2,15–24] the same studies have shown that the amount of improvement for most measures is less than after initial cataract surgery. This leads to the following questions: How much benefit is gained from second-eye cataract surgery? Does this benefit after second-eye surgery justify the expenditure of approximately 4% of the Medicare budget?[27]

Cost-utility analysis is a relatively new methodology that has been used to provide insight to questions regarding benefit and cost-effectiveness[28–35] (see Appendix for basic terminology). This modality is unique because it compares medical and surgical care across all specialties by using a common denominator: the cost per quality-adjusted life-year ($/QALY) gained. The cost for a given procedure is derived from the hospital and facility fees, physician fees, and pharmaceutical fees. The number of QALYs calculated for a given therapeutic intervention is derived from evidence-based data and synthesized with patient-based preferences and perceptions of quality of life (utility values). This is measured with a standardized scale from 1.0, representing a perfect health state, to 0.0, representing death.[33–35] For example, a patient with a utility value of 0.88 has a better quality of life than a patient with a utility value of 0.43. The utility value change after a certain therapeutic procedure is considered the benefit of the therapy to the patient. This theoretical model has been used across a broad range of medical specialties.[36–39] Its recent use in ophthalmology has allowed a uniform assessment for many ophthalmic procedures, as well as a comparison of these interventions with others in different medical specialties.[13,40–44]

It has been demonstrated in a population study that quality of life is directly proportional to the Snellen acuity in the better-seeing eye.[28] The utility value for a given Snellen acuity was found to be independent of particular ocular health state, length of time of disease, age, race, education, sex, and socioeconomic status. These data comprised the basis for the cost-utility analysis of initial cataract surgery.[13] Initial cataract extraction was found to be extremely cost-effective by using the visual acuity outcomes from the U.S. National Cataract Patient Outcomes Research Team (PORT).[4,13] This result was anticipated because cataract is typically a bilateral, vision-decreasing disease, and removal of one cataract typically improves vision, often establishing the operated eye as the better-seeing eye.

The question of cost-effectiveness for second-eye cataract surgery is the substance of this study. In light of recent research revealing a substantial increase in utility state and quality of life in patients with bilateral good vision compared with unilateral good vision,[45] a cost-utility analysis of second-eye cataract surgery was undertaken by using identical, expected visual acuity outcomes from initial cataract surgery[4,13] and utility values associated with the change from unilateral to bilateral good vision.[45] This methodology, although it measures the cost-utility of cataract surgery in the second eye, also applies to situations in which there is good vision in one eye (not necessarily after cataract surgery) and diminished vision in the other eye secondary to a cataract.

Materials and Methods

Patient Population and Visual Acuity Data

Visual acuity data for patients undergoing cataract extraction were taken from the report of the U.S. National Cataract PORT.[4] As in the study on cost-effectiveness of initial cataract extraction,[13] only the 722 patients in the U.S. arm of this study were used for analysis in this study. The U.S. cohort was selected because of its similarity to current practice patterns in the United States (i.e., more than two thirds of patients in the U.S. arm of the PORT received phacoemulsification as opposed to extracapsular cataract extraction).

Cataract Complications

Identical complication rates associated with cataract extraction, as described by Busbee et al[13] for cost-effectiveness in initial cataract surgery, were used in this study. The same complication rates were used in an attempt to approach standardization between the two studies. It was also believed that the same studies used for the initial cataract extraction were among the best evidence-based data for each complication.

In essence, the complications considered for the two studies included posterior capsular opacification (PCO), endophthalmitis, cystoid macular edema, lost lens fragments, intraocular lens dislocation, retinal detachment, intraocular lens dislocation, pseudophakic bullous keratopathy, and PCO with subsequent retinal detachment. The PORT data ended with 4-month visual acuity data and, therefore, included the visual sequelae of complications typically occurring within this 4-month window after surgery. The authors assumed that endophthalmitis, macular edema, and lost lens fragments typically occurred within this 4-month window and that these complications were already factored into the mean Snellen acuity of 20/27 in the U.S. cohort.[4]

PCO was assumed to occur at the rate of 28% over a 5-year postoperative period. The mean time of treatment after surgery was

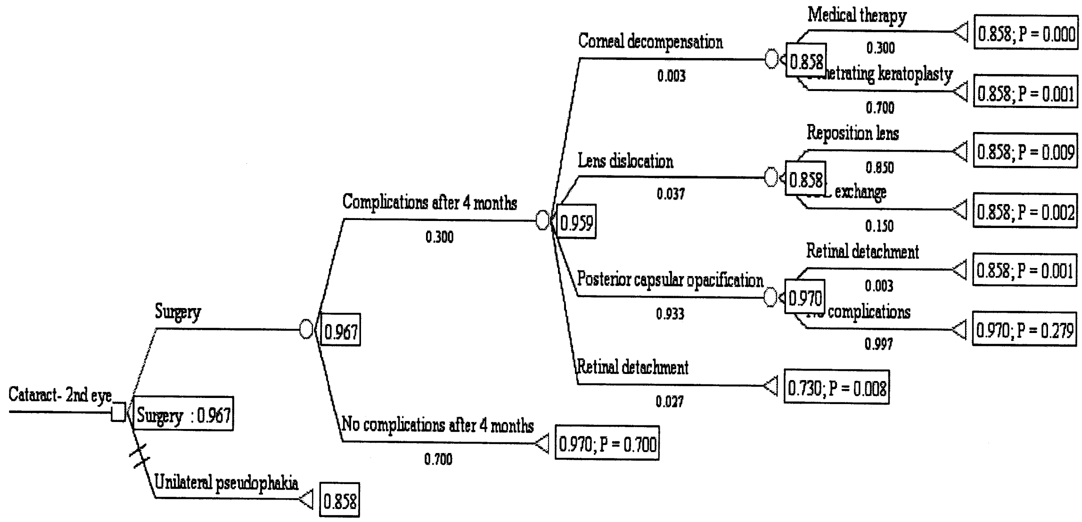

Figure 1. Decision-analysis tree for second-eye cataract surgery. Utility values are located to the right of the decision nodes (triangles). The incidences of events are shown below the arms in the tree. P = probability of an outcome.

assumed to be 2 years.[46] Retinal detachment was assumed to occur at a rate of 0.81% after cataract surgery. The mean time of retinal detachment repair was assumed to occur 1 year after surgery.[47] It was assumed that the repair of the retinal detachment occurred 1 year after the yttrium–aluminum–garnet capsulotomy. Thus, retinal detachment repair after treatment of PCO was presumed to occur 3 years after cataract surgery. Intraocular lens dislocation was assumed to occur at a rate of 1.1% after cataract extraction.[47] Pseudophakic bullous keratopathy was assumed to occur at a rate of 0.3%, and the presumed mean time to postoperative treatment was 1 year after cataract extraction.[47] PCO with subsequent retinal detachment was assumed to occur at a 3.9-fold increase from the cumulative retinal detachment rate of 0.81%.[47,48]

The visual outcomes for each complication after treatment, with the exception of PCO, were assigned a utility value of 0.858, or 20/27. This corresponded with the utility value of the initial pseudophakic eye, because it was assumed that the complications in the operated eye would produce a visual acuity <20/27. Thus, utility value was assigned to the previously operated, better-seeing eye.[28] For PCO without retinal detachment, it was assumed that visual acuity returned to 20/27 in the operated eye. This resulted in a utility value of 0.97, associated with bilateral 20/27 visual acuity (Fig 1).

Utility Value Data

Utility values were based on data from a large study of patients with ophthalmic disease.[28] These utility values correspond to the better-seeing eye and particularly influence the utility value after a cataract complication in the second eye (Fig 1). Utility values associated with subsequent good visual acuity in both eyes after uneventful cataract extraction were based on a recent study that compared the utility change from unilateral good vision (i.e., 20/25 or better in one eye) vs. bilateral good vision (i.e., 20/25 or better vision in both eyes).[45]

All utility values were derived from patient preferences by using a time trade-off model. This methodology has been thoroughly described in the literature in regard to its use in ophthalmic diseases and specific visual acuity states.[28–31,40–44] Essentially, it is a method by which a patient determines the quantity of life he or she would sacrifice to have the quality of life associated with permanent 20/20 vision in each eye (a utility state defined[28] as 1.0). The proportion of remaining years of longevity a patient would sacrifice to achieve 20/20 vision is subtracted from 1.0 to yield the patient's current ocular utility value.

Synthesis of Visual Acuity and Utility Value Data

Decision analysis incorporating utility values was performed by using software produced by Treeage, Inc.[49] The clinical situation of cataract extraction with intraocular lens implantation was simulated in the decision analysis tree.[50] Because cataract surgery is definitive (i.e., the recurrence rate of cataract is 0), Markov modeling was not used in this cohort. Considering that there is no prospective study that reports on Snellen visual acuity outcomes for second-eye cataract extraction and that patients in this model had preexisting unilateral pseudophakia, the authors made two assumptions in the model. First, it was assumed that the theoretical patient presented with visual acuity in the pseudophakic eye equal to the mean postoperative visual acuity as reported by the PORT study.[4] The authors believe that this assumption is accurate because of the results of the randomized, prospective PORT study, which accounts for perioperative complications that could affect visual outcome. Although individual cataract outcomes can certainly vary, the mean visual acuity found in that study was 20/27 for either eye. Second, it was assumed that the postoperative visual acuity for the second-eye surgery was equal to that of the first eye (i.e., 20/27, as reported by the PORT study[4]). Therefore, the postoperative visual acuity of 20/27 was used for both the initial and the second-eye cataract surgery.

Complications associated with cataract surgery, the rates of adverse events as determined by the authors, and mortality within the group of patients were incorporated into the microcomputer model that performed decision analysis (Fig 1). The median age in the PORT study was 73 years. This number was applied to current life tables to determine life expectancy.[51]

Medical Costs

The health care costs associated with each of the primary costs of cataract surgery and the costs of defined cataract complications were derived from multiple sources. The provider fees, as defined by the year 2001 Current Procedural Terminology data and the payments by the Health Care Financing Administration in nominal U.S. dollars, encompass the expenses associated with physician work, practice expense, and malpractice expense.[52,53] Drug expenditure costs associated with cataract surgery, including the medical and postoperative managements associated with cataract surgery, were obtained from the average wholesale prices as defined in the *2001 Drug Topics Red Book*.[54] Institutional costs associated with surgical procedures or inpatient admissions were separated into two categories. First, the costs associated with ambulatory procedures, encompassing most of the surgical procedures mentioned in this study, were obtained from the Medicare 2001 outpatient facility fee schedule.[55] The second group of facility costs, relating to retinal procedures that were assumed to be performed uniformly as inpatient admissions, were assigned[55] to diagnosis-related group 36 (Table 1).

When multiple evidence-based treatment options were available for the management of complications associated with cataract surgery, an estimation of the costs for a certain complication was derived from the weighted average of the costs relating to each treatment option. The frequency of using a certain management option was estimated by using prior studies relating to treatment of a certain complication. For PCO, yttrium–aluminum–garnet capsulotomy was used as the only management option for this entity.[57] In the case of endophthalmitis, it was assumed that 80% of patients received vitreous tap and antibiotic injection and that 20% of patients received vitrectomy and antibiotic injection.[58] For cystoid macular edema, it was assumed that all patients were treated with topical ketorolac and prednisolone. In the case of lost lens fragments, all patients were assumed to be managed with vitrectomy and retrieval of the lens material. For retinal detachment either with or without a capsulotomy, management was assumed to be split equally between a scleral buckling procedure and pars plana vitrectomy (Brown GC, personal communication, 2000). In the case of dislocation of the intraocular lens, it was assumed that 89% of patients had repositioning or exchange alone, whereas 11% of patients had repositioning or exchange and vitrectomy.[59] Pseudophakic bullous keratopathy was assumed to be managed by penetrating keratoplasty in 70% of patients and by topical medications alone in 30% of patients.[60]

The outlay of dollars for cataract surgery, endophthalmitis, intraocular lens dislocation, cystoid macular edema, and lost lens fragments was assumed to occur in close proximity to the initiation of cataract management. For these entities, the present (2001) value of money was used. In the cases in which complications were assumed to occur some designated time after surgery, a 3% annual discount rate was used to account for the time value of money. For example, a penetrating keratoplasty for pseudophakic bullous keratopathy performed 1 year after cataract surgery would be discounted from its present value of $2866 to the value of the monetary outlay 1 year later, equaling $2763 (Table 1).

Cost-Utility Analysis

The total utility gain from receiving second-eye cataract surgery, including the potential complications, was converted into QALYs gained by multiplying the utility change by the number of years the typical patient would expect to live.[33] This accounts for the duration of benefit for the procedure. The total cost, including the weighted average of all procedures associated with complications, divided by the QALYs results in the standardized unit for cost-effectiveness in this model: the cost per QALY gained.

Results

The reference case utility value for an ocular health state after second-eye cataract surgery was 0.967. This took into account all complications associated with performing cataract surgery on the second eye. The utility value corresponding to unilateral pseudophakia has been shown to be 0.858.[13] The difference between these two health states—unilateral and bilateral pseudophakia—equaled a 0.109 net utility gain. This gain, multiplied by the 12-year life expectancy of the typical patient, resulted in 1.308 QALYs gained from second-eye cataract surgery. Discounting the QALYs gained by an annual 3% rate resulted in 0.92 QALYs gained.

The costs of cataract surgery with a weighted average of all complications resulted in a total health care cost of $2509. The costs were individually discounted at a 3% annual rate, depending on the time of treatment in relation to the cataract surgery. The cost-effectiveness of second-eye cataract surgery was calculated to be $2727 per QALY gained for the reference case.

One-way sensitivity analysis was performed by varying utility values, costs, and discounting rates. Increasing discounted costs by 25% resulted in $3408 per QALY gained, whereas decreasing the costs by 25% resulted in $2045 per QALY gained. When all utility values were increased by 25%, the cost-effectiveness was $2182 per QALY gained. By decreasing all utility values by 25%, the cost-effectiveness was $3646 per QALY gained. Varying the annual discount rate resulted in $1918 per QALY gained for a 0% rate, $3445 per QALY gained for a 5% rate, and $5964 per QALY gained for a 10% rate.

Discussion

The results from this study suggest that cataract surgery in the setting of unilateral pseudophakia is an extremely cost-effective procedure. By using patient preference–based data and decision analysis, this procedure also seems to be among the most cost-effective procedures across all medical specialties (Table 2). Although there are no standardized definitions of what is considered cost-effective, it has been suggested that procedures costing <$20 000 per QALY gained are highly cost-effective, whereas those costing >$100 000 per QALY gained are not cost-effective.[61] Even these standards must be interpreted loosely because these guidelines were set in the early part of the 1990s and are based on the Canadian health care system. Probably a more effective way to evaluate these data is to compare them with other studies that used patient-preference based QALYs and the total costs of the given procedure.

The U.S. health care system continually encounters reminders of the potential future collision course between medical care and societal expenditures. The annual health care budget currently consumes 14% of the Gross Domestic Product, and this has been projected to increase to 16% to 20% within this decade.[14,62] Additionally, the World Health Organization has recently rated the U.S. health care system 37th in the world when evaluating the efficiency with which medical resources are used. The same report rated the United States first in health care costs associated with delivery.[63] It is statistics like these that lead this research and many other ongoing research projects to critically answer the questions already posed in this article. First, what is the benefit that is gained from second-eye cataract surgery?

Table 1. Medical Costs (Year 2001 Nominal U.S. Dollars) and CPT Codes

Service	CPT Code[52]	Discounted Cost[53]
Cataract surgery		
Initial office consultation	99254	$ 148
A-scan with IOL calculation	76519	$ 81
Cataract extraction	66984	$ 743
Ambulatory surgical center fee	NA	$ 928
Postoperative medications	NA	$ 54
Anesthesia fees[56]	NA	$ 360
Total		$2314
Posterior capsular opacification		
YAG capsulotomy	66821	$ 210
Postlaser medications	NA	$ 21
Total		$ 231
Endophthalmitis—tap and inject		
Initial office consultation	99254	$ 148
Vitreous tap	67010	$ 450
Vitreous drug injection	67028	$ 183*
Postprocedure medications	NA	$ 63
Total		$ 844
Endophthalmitis—pars plana vitrectomy		
Initial office consultation	99254	$ 148
Pars plana vitrectomy	67036	$ 868
Vitreous drug injection	67028	$ 183*
Inpatient facility fee	DRG 36[55]	$2825
Postoperative medications	NA	$ 63
Anesthesia fees[56]	NA	$ 648
Total		$4735
IOL dislocation		
IOL repositioning	66825	$ 663
Ambulatory surgical center fee	NA	$ 928
Postoperative medications†‡§	NA	$ 84
Anesthesia fees[56]	NA	$ 360
Total		$2035
IOL dislocation with pars plana vitrectomy		
Initial office consultation	99254	$ 148
Pars plana vitrectomy	67036	$ 868
IOL repositioning	66825	$ 332*
Inpatient facility fee	DRG 36[55]	$2825
Postoperative medications†‡§	NA	$ 84
Anesthesia fees[56]	NA	$ 648
Total		$4757
Cystoid macular edema		
Topical medications§‖	NA	$ 201
Total		$ 201
Pseudophakic bullous keratopathy—surgical		
Initial office consultation	99254	$ 144
Penetrating keratoplasty	65730	$1046
Ambulatory surgical center fee	NA	$ 901
Postoperative medications†‡§	NA	$ 82
Anesthesia fees[56]	NA	$ 611
Total		$2763
Pseudophakic bullous keratopathy—medical		
Lifetime topical medication¶	NA	$1319
Total		$1319
Lost lens fragments		
Initial office consultation	99254	$ 148
Pars plana vitrectomy	67036	$ 868
Inpatient facility fee	DRG 36[55]	$2825
Postoperative medications†‡§	NA	$ 84
Anesthesia fees[56]	NA	$ 648
Total		$4573
RD—scleral buckle		
Initial office consultation	99254	$ 144
RD repair—scleral buckle	67107	$1102
Inpatient facility fee	DRG 36[55]	$2743
Postoperative medications†‡§	NA	$ 82
Anesthesia fees[56]	NA	$ 629
Total		$4700
RD—vitrectomy		
Initial office consultation	99254	$ 144
RD repair—vitrectomy	67108	$1520
Inpatient facility fee	DRG 36[55]	$2743
Postoperative medications†‡§	NA	$ 82
Anesthesia fees[56]	NA	$ 629
Total		$5118

*Only 50% of the second procedure was included per Medicare guidelines.
†One 5-ml bottle of prednisolone acetate drops.
‡One 5-ml bottle of atropine drops.
§One 5-ml bottle of ciprofloxacin drops.
‖Two 5-ml bottles of ketorolac drops.
¶A total of 125 5-ml bottles of 5% sodium chloride solution (estimated lifetime supply).
CPT = Current Procedural Technology; DRG = diagnosis-related group; IOL = intraocular lens; NA = not applicable; RD = retinal detachment; YAG = yttrium–aluminum–garnet.

Second, does this benefit after second-eye surgery justify the large governmental and societal expenditure?

The authors believe that this research complements the large body of literature answering the first question in defining the benefit of second-eye cataract surgery. The benefit has been shown from a functional standpoint of the patient[2,15–21] and from improvements in quality of life measures.[2,21–26] The methodology presented herein adds another dimension to the substance of quality-of-life discussions. Unlike other questionnaires that assess patient preference and functionality,[7,8,10,12] the nature of questioning that uses the time trade-off method[28] allows the patient to include intangible values into his or her own health state. This can encompass emotional status, family support, fear

Table 2. Comparison of Cost-Effectiveness by Using Quality-Adjusted Life-Years (QALY) for Procedures across Medical Specialties

Therapeutic Intervention	U.S. Dollars/ QALY Gained
Laser photocoagulation for threshold ROP	688[43]
Cryotherapy for threshold ROP	1801[43]
Initial cataract surgery	2023[13]
Second-eye cataract surgery	2727
Laser photocoagulation for subfoveal CNV	5629[41]
Coronary bypass—single-vessel LAD	6985[35]
Laser photocoagulation for extrafoveal CNV	12,005*
Cochlear implant	17,153[36]
Uncomplicated stage 3 macular hole surgery	34,585†
Liver transplantation	332,413[28]
Antibiotic prophylaxis for dental procedure	1,370,250[38]
AC paracentesis and CO_2/O_2 therapy for CRAO	3,800,000[31]

*Presented at the annual Association for Research in Vision and Ophthalmology meeting, May 2000, by Busbee B et al.
†Presented at the annual American Academy of Ophthalmology meeting, October 2000, by Busbee B et al.
AC = anterior chamber; CNV = choroidal neovascularization; CRAO = central retinal artery occlusion; LAD = left anterior descending; ROP = retinopathy of prematurity.

of the unknown, individual socioeconomic implications, and many other unknown factors that may influence a patient's daily life. It has been suggested by other researchers[64] that this methodology might provide a more holistic view of a patient's health state. These factors could very well explain the wide disparity that has been found between physicians' perceptions of disease states and patients' perceptions of the same entities.[65–68] The acknowledgment of these differences between patients and third parties and the use of patient preference–based utilities have helped to definitively define the benefit of second-eye cataract surgery.

In answering the second question concerning the value of second-eye cataract surgery in the face of large societal costs, cost-utility analysis becomes an invaluable tool. It provides the groundwork for value-based medicine,[69] measuring the patient-perceived value conferred by a health care intervention for the resources expended. This methodology allows a common denominator, cost per QALY gained, to compare the cost-effectiveness of second-eye cataract surgery with that of other procedures in ophthalmology and across other medical specialties (Table 2). The results from this study suggest two conclusions in regard to value. The first conclusion is that second-eye cataract surgery, at $2727 per QALY gained, seems to be nearly as valuable as initial cataract surgery, at $2023 per QALY gained.[13] This alone disputes an earlier report that suggested otherwise by proposing the elimination of reimbursement for second-eye cataract surgery.[70] It should also be noted that in both initial and second-eye cataract surgery, varying costs or utility values up to 25% did not appreciably change the relationship between the cost-effectiveness of initial and second-eye cataract surgery. The second summation that relates to the cost-effectiveness of second-eye cataract surgery is that this procedure, as well as initial cataract surgery, ranks among the most cost-effective interventions that have been evaluated with this methodology. For example, even though the costs of cataract surgery greatly exceed the costs associated with 3 days of chemoprophylaxis for prosthetic patients during dental treatment, the cost-effectiveness of the latter procedure is $1 350 000 per QALY gained.[38] Similarly, the cost-effectiveness of anterior chamber paracentesis and carbon dioxide/oxygen inhalation in the setting of central retinal artery occlusion is $3.8 million per QALY gained.[31] These extreme examples illustrate that not every procedure with a minimal cost has a similar cost-effectiveness.

As in any study, the authors acknowledge weaknesses in both the methodology and the specific research herein. The authors realize that the analysis of costs associated with cataract surgery could be considered incomplete because the analysis was performed from the perspective of a third-party insurer. Societal costs—encompassing workforce lost from a procedure, possible disability claims, and any other type of public monetary service—were not addressed in this model. It should also be noted that the utility values for this methodology are not based solely on a cataract population. Rather, a broad range of ophthalmic diseases were included in the gathering of utility values, including a substantial number of patients with irreversible retinal disease. One could argue that these patients would put more value on regaining better vision because of the knowledge that their disease state is not reversible. This could potentially inflate the utility value for good vision and, thus, inflate its cost-effectiveness. This is countered, however, by the finding that ocular utility values seem to be largely independent of the underlying cause of visual loss.[28,71] Additionally, most utility values do not vary with length of time of disease, gender, age, or education level.[28] The sensitivity analysis associated with this study also supports a robust cost-utility analysis. Decreasing the utility values by 25%, correcting in theory for any inflation of utility values, increases the cost-effectiveness of second-eye cataract surgery only minimally, to $3464 per QALY gained. This proves to still be among the most cost-effective procedures in medicine. Finally, one could argue that the entire concept behind utility values is too abstract to be applicable. Conversely, the authors believe that the length of life remaining and willingness to sacrifice a proportion of time for a better life is a universal concept grasped by almost everyone. This streamlines the answers into a numeric value that can be placed into a microcomputer model. This system is admittedly not perfect, but because cost-containment pressures cause physicians to justify their methods of treatment, cost-utility analysis is an available methodology that can answer societal questions regarding the delivery of health care.

In summary, second-eye cataract surgery seems to be one of the most cost-effective procedures in ophthalmology and across medical specialties. This is not surprising, because patients uniformly value their vision for daily life. Modern cataract surgery affords this improvement in vision and visual function. The assumption of benefit from second-eye cataract surgery that is evident to every practicing ophthalmologist might be conferred to others outside of the specialty by this understandable method of evaluating costs and therapeutic interventions. This includes patients, other physicians, insurance providers, and policymakers who will define the practice of medicine in the 21st century.

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Appendix: Terminology Used in Cost-Utility Analysis

Cost-utility analysis. A method of health care economic analysis that quantitatively measures the resources expended for, and the value gained from, an intervention. It is typically in terms of cost per quality-adjusted life-year gained.

Decision analysis. A process that determines the most probable outcome of an intervention by combining the probabilities of specific possible outcomes related to that intervention.

Discounting. A financial tool used to account for the time value of money and health care outcomes in health care economic analyses. It is based on the concept that a dollar now or good health now is worth more than one in the future because it can be invested to yield a return over time.

Evidence-based medicine. Medical practice based on the highest-quality, most reproducible clinical data. The gold standard for interventional evidence-based medicine is the randomized clinical trial with low type I and type II errors.

Quality-adjusted life-year. Calculated by multiplying the change in utility value (overall measure of a patient's perception of well-being) conferred by an interventional therapy by the expected duration (in years) of the treatment benefit or harm.

Time trade-off utility analysis. A methodology of utility value measurement in which a person is first asked how many additional years of life he or she expects to live. The person is then asked how many of those years, if any, he or she would be willing to trade in return for a perfect health state. The utility value is then calculated by subtracting the proportion of remaining years traded from 1.0. For example, a person who has 20/80 vision in each eye who is willing to trade 3 of 10 remaining years of life in return for perfect vision in each eye would have a time trade-off utility value of 0.70 ($1.0 - 3/10$).

Sensitivity analysis. A methodology of examining outcomes when variables such as cost, utility values, and discount rate are changed. One-way sensitivity analysis involves the change of one variable; two-way sensitivity analysis involves the simultaneous change of two variables, and so on.

Utility (or utility value). A measure of the person's quality of life associated with a health state, with perfect health assigned a value of 1.0 and death a value of 0.0. For ocular conditions, 1.0 is associated with a perfect long-term visual health state, and 0.0 is associated with death.

Value-based medicine. Medical practice based on the patient-perceived value (improvement in quality of life, length of life, or both) conferred by an intervention for the resources expended. Cost-utility analysis is the hallmark of value-based medicine.