Journal of the American College of Cardiology
© 2004 by the American College of Cardiology Foundation
Published by Elsevier Inc.

Vol. 43, No. 7, 2004
ISSN 0735-1097/04/$30.00
doi:10.1016/j.jacc.2003.11.030

Economic Analysis of a Transesophageal Echocardiography-Guided Approach to Cardioversion of Patients With Atrial Fibrillation

The ACUTE Economic Data at Eight Weeks

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OBJECTIVES The aim of this study was to compare the relative cost of a transesophageal echocardiography (TEE)-guided strategy versus conventional strategy for patients with atrial fibrillation (AF) >2 days duration undergoing electrical cardioversion over an eight-week period.

BACKGROUND The Assessment of Cardioversion Using Transesophageal Echocardiography (ACUTE) trial found no difference in embolic rates between the two approaches. However, the TEE-guided strategy had a shorter time to cardioversion and a lower rate of composite bleeding. While similar clinical efficacy was concluded, the relative cost of these two strategies has not been explored.

METHODS Two economic approaches were employed in the ACUTE trial. The first approach was based on hospital charge data from complete hospital Universal Billing Code of 1992 forms, a detailed hospital charge questionnaire, or imputation. Regression analysis was used to investigate the added cost of adverse events. The second economic approach involved the development of an independent analytic model simulating treatment and actual ACUTE outcome costs as a validation of clinically derived data. Sensitivity analysis was performed on the analytic model to investigate the potential range in cost differences between the strategies.

RESULTS A total of 833 of the 1,222 patients were enrolled from 53 U.S. sites; TEE-guided (n = 420) and conventional (n = 413). At eight-week follow-up, total mean costs did not significantly differ between the two groups, respectively ($6,508 vs. $6,239; difference of $269; p = 0.50). Cumulative costs were 24% higher in the conventional group, primarily due to increased incidence of bleeding and hospital costs associated with bleeding. A separate analytic model showed that treatment costs were higher for the TEE-guided strategy, but outcome costs were higher for the conventional strategy. Sensitivity analysis of the analytic model illustrated that varying the incidence and cost of major bleeding and the cost of TEE had the greatest impact on cost differences between the two groups.

CONCLUSIONS In patients with AF >2 days duration undergoing electrical cardioversion, the TEE-guided group showed little difference in patient costs compared with the conventional group. The TEE strategy had higher initial treatment costs but lower outcome-associated costs. Cumulative costs were 24% higher in the conventional group, primarily due to bleeding. The TEE-guided strategy is an economically feasible approach compared with the conventional strategy. (J Am Coll Cardiol 2004;43:1217–24) © 2004 by the American College of Cardiology Foundation

Atrial fibrillation (AF) is the most common arrhythmia seen in clinical practice in the U.S. affecting 2.3 million Americans (1,2). By 2050, it is projected that over 5.6 million Americans will have AF with over 50% of subjects being 80 years or older (2). Atrial fibrillation is important since it contributes to the incidence of ischemic stroke, heart failure, and mortality. Thus, AF is considered as a new epidemic with significant public health implications (3). However, the overall economic burden of treating AF is not well known.

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Electrical cardioversion is used to restore sinus rhythm, but the procedure itself may be associated with an increased risk of stroke in patients with AF >2 days' duration (4–6). Transesophageal echocardiography (TEE) with short-term anticoagulation has been proposed as an alternative to the conventional strategy of seven to eight weeks of anticoagulation in this group of patients (7,8).

The Assessment of Cardioversion Using Transesophageal Echocardiography (ACUTE) trial was a randomized study that compared the TEE-guided approach to the conventional approach (9,10). There was no difference in composite embolic events between groups; however, the composite bleeding rate was significantly lower in the TEE-guided group. An important secondary end point of the study was the relative cost of the two management strategies over an

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Manuscript received September 25, 2002; revised manuscript received February 28, 2003, accepted November 17, 2003.

Abbreviations and Acronyms

ACUTE = Assessment of Cardioversion Using Transesophageal Echocardiography trial
AF = atrial fibrillation
CPI = Consumer Price Index
ICER = incremental cost-effectiveness ratio
QALY = quality-adjusted life year
TEE = transesophageal echocardiography
TTE = transthoracic echocardiography
UB92 = Universal Billing Code of 1992

eight-week period (9). We now present a detailed prospective economic analysis of the ACUTE trial.

METHODS

Patient population. Of the 1,222 patients in the ACUTE trial, 833 (68%) were enrolled in the U.S. and comprised the study population for the economic analysis. Only U.S. patients were enrolled in the economic substudy of the ACUTE trial due to vastly different healthcare systems and associated costs between countries. The study design and clinical outcomes manuscripts for the ACUTE trial have been previously published (9,10). Patients were randomly assigned to either the TEE-guided strategy or the conventional anticoagulation strategy (Fig. 1). The institutional review board approved the study at each participating site, and informed consent was obtained from all patients (10).

Economic methodology. Two economic approaches were employed in the ACUTE trial (11–14). The first approach was based on hospital charge data from the date of enrollment through eight-week follow-up. Where possible, treatment and outcome costs were derived for this time period directly from complete hospital Universal Billing Code of 1992 (UB-92) forms for both inpatient and outpatient visits. In the absence of UB92s, hospitals were asked to generate a detailed hospital charge questionnaire indicating total charges (including technical and professional components) for all patient admissions and visits during the study period. The charges in the questionnaires were based on hospital bills. For any U.S. patient where neither UB92s nor hospital charge questionnaires were available, multivariable linear regression, based on the charge details derived above, was used to impute missing patient charge information (14). Because hospital charges often include a profit margin and are not equivalent to actual costs, the standard approach of charge conversion using hospital-specific cost-to-charge ratios was utilized (11,15). Physician costs (19.6% of hospital costs) were added to converted hospital charges to obtain total patient treatment costs (16,17). The Consumer Price Index (CPI) annual inflation rate was used to adjust all costs to the year 2000 U.S. dollars. A discount rate of 3% was also used, where applicable.

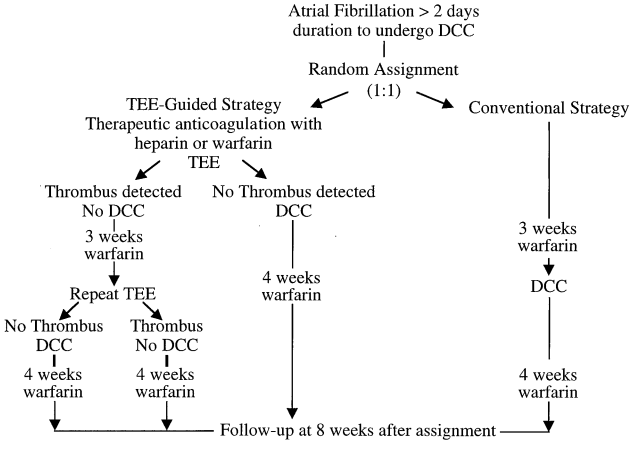

Figure 1. A diagram illustrating the Assessment of Cardioversion Using Transesophageal Echocardiography trial (ACUTE) protocol. Patients were randomly assigned to either a transesophageal echocardiography (TEE)-guided or conventional group; TEE-guided patients, without thrombus by TEE, received early cardioversion with short-term therapeutic anticoagulation. Transesophageal echocardiography-guided patients with thrombus received three weeks anticoagulation and repeat TEE. Conventional patients received no TEE and three weeks anticoagulation before cardioversion. All patients received four weeks of therapeutic anticoagulation after cardioversion. DCC = direct current cardioversion.

The second economic approach was implemented to validate the results of the hospital charge method described above. It involved the development of an analytic model simulating treatment and outcome costs for the 833 U.S. patients in the ACUTE trial. This analysis parallels previous investigation on model costs (12,13). Actual treatment and outcome probabilities were derived from the U.S. patient population (10). The outcome costs included the cost of an embolic stroke, major and minor bleeding, and death. These costs were adjusted to the year 2000 U.S. dollars using the CPI and discounted at an annual rate of 3%. These costs were obtained from the following sources:

1) Mean hospital and physician charges derived from the Cleveland Clinic Foundation cost accounting system (converted using appropriate cost-to-charge ratios for costs related to anticoagulation blood tests, direct current cardioversion, warfarin, and hospitalization, based on length of stay derived for the ACUTE study;
2) Medicare reimbursement (for transthoracic echocardiography [TTE] and TEE costs);
3) Published sources (for cerebrovascular accident, transient ischemic attack, bleeding, and death) (12,18).

Sensitivity analysis was performed on the analytic model to investigate the potential range in cost differences between the TEE-guided and conventionally treated groups. A one-way sensitivity analysis was performed by varying the incidence and cost of stroke, major and minor bleeding, and death observed in the ACUTE trial. A range of TEE costs was also investigated, as this was an additional cost incurred only to the treatment group and has the potential to affect the cost effectiveness of the TEE-guided treatment compared with conventional treatment.

Statistical analysis. Differences in mean costs between the treatment groups (TEE minus conventional) were compared on an intention-to-treat basis (19). For categorical

Table 1. Baseline Clinical Data for U.S. Patients Enrolled in the ACUTE Trial on Cost Analysis

Variables	TEE-Guided (n = 420)	Conventional (n = 413)
Age, yrs	67 ± 12	66.6 ± 13
Male gender, n (%)	295 (71)	288 (71)
Inpatients, n (%)	308 (73)	295 (71)
Functional status (DASI score)	31 ± 13	29 ± 18
Hypertension, n (%)	245 (60)	246 (61)
Congestive heart failure, n (%)	120 (29)	129 (32)
NYHA class III or IV, n (%)	61 (20)	58 (20)
Left ventricular ejection fraction, (%)	49 ± 16	48 ± 16
Previous cardioversion, n (%)	50 (12)	52 (13)
Previous embolic event, n (%)	30 (7)	41 (10)
Rhythm at enrollment, n (%), AF/atrial flutter	401 (95)/19 (5)	392 (95)/21 (5)
Estimated duration of AF, days median (interquartile range)	8 (4–26)	9 (4–25)
Left atrial area, cm^2	24.7 ± 7.3	24.9 ± 7.5

Data presented as mean ± SD, n (%), or median (interquartile range). No statistically significant difference for all comparisons. Patients with AF were randomly assigned to either a transesophageal echocardiography-guided and/or conventional strategy.

AF = atrial fibrillation; DASI = Duke Activity Status Index; NYHA = New York Heart Association; TEE = transesophageal echocardiography.

variables, analysis included frequencies and percentages. For continuous variables, analysis included the mean and SD. Because the data were not normally distributed, the bootstrap method was used to derive sample means and bias-corrected confidence levels for 1,000 samples with replacement (19,20). Analysis of variance methods were used to determine if costs varied between treatment groups in the overall population as well as in the subsets of patients who had clinical events. Unless otherwise stated, statistical testing was conducted using two-sided alternatives with a type I error of 0.05.

RESULTS

Baseline characteristics. Of 833 patients included in the economic substudy of the ACUTE trial, 420 patients belonged to the TEE-guided group and 413 patients to the conventional group. The baseline clinical characteristics of these patients were well matched (Table 1).

Overall hospital and physician-derived costs. Table 2 shows the total hospital and physician-derived costs between the TEE-guided and conventional groups for the 833 patients using the charge data derived from UB92s, charge questionnaires, and from multivariable linear regression. A total of 369 patients (44%) from 20 sites had complete UB-92s; 107 patients (13%) from 10 sites lacked complete UB-92s but had total hospital charges summarized in the ACUTE questionnaire. A total of 357 patients (43%) had neither UB-92s nor completed patient questionnaires, and, therefore, their cost data were imputed using multivariable linear regression techniques. The multivariable model can be found in the Appendix of this paper. The confidence intervals associated with the bootstrap sample replication and related p values are also indicated in Table 2.

Overall, there was no significant difference in the mean derived eight-week total costs between the TEE-guided and conventional groups ($6,508 vs. $6,239; mean difference of

Table 2. Total Mean Hospital- and Physician-Derived Costs of TEE-Guided and Conventional Management Strategies for 833 U.S. Patients Over an Eight-Week Pericardioversion Period

					Bootstrap Results		
Total Derived Costs	TEE-Guided	Conventional	Difference	p Value	Mean Cost Difference	95% CI	p Value
n = 833							
Mean ± SD	$6,508 ± 4,917	$6,239 ± 6,370	$269	0.50	$386	−$486 to $985	0.503
Costs from hospital/physician bills n = 369							
Mean ± SD	$7,199 ± 6,155	$6,808 ± 8,660	$391	0.62	$841	−$1,434 to $1,900	0.642
Costs from questionnaires n = 107							
Mean ± SD	$5,158 ± 3,164	$5,455 ± 5,838	−$297	0.73	$868	−$2,284 to $1,212	0.666
Costs from linear regression n = 357							
Mean ± SD	$6,089 ± 3,409	$5,960 ± 3,120	$129	0.71	$350	−$551 to $874	0.678

Data are presented in U.S. dollars. Also shown are patient subsets indicating costs derived from hospital/physician charges (n = 369), patients with costs derived from questionnaires (n = 107), and patients with costs derived from the linear regression (n = 357); Bootstrap results of 1,000 samples (bias corrected) with replacement for the difference in mean cost comparisons for total ACUTE population and each patient subset are included.

CI = confidence interval; TEE = transesophageal echocardiography.

Table 3. Mean Costs and Added Costs* for Treatment of Patients' Adverse Events During the Eight-Week Study Period in the ACUTE Clinical Trial

Event	Mean Costs			Added Costs		
	TEE-Guided	Conventional	p Value	Incremental Costs	95% CI	p Value
CVA	(n = 4)	(n = 2)				
Mean ± SD	17,713 ± 9,035	11,673 ± 2,480	0.43	$5,756	$1,526 to $9,986	0.008
CVA/TIA	(n = 5)	(n =3)				
Mean ± SD	16,003 ± 8,708	10,898 ± 2,208	0.37	$5,194	−$1,549 to $8,840	0.005
Major bleed	(n = 5)	(n = 8)				
Mean ± SD	24,902 ± 9,379	22,004 ± 17,396	0.74	$16,285	$13,364 to $19,206	< 0.001
Minor bleed	(n = 7)	(n = 20)				
Mean ± SD	12,057 ± 12,431	12,311 ± 10,441	0.96	$4,492	$2,485 to $6,499	< 0.001
Composite bleed	(n = 11)†	(n = 28)				
Mean ± SD	15,609 ± 11,544	15,080 ± 13,231	0.91	$8,487	$6,720 to $10,253	< 0.001
Cardiac death	(n = 5)	(n = 2)				
Mean ± SD	10,259 ± 5,259	11,796 ± 13,309	0.82	$3,769	−$124 to $7,662	0.058
Noncardiac death and UNK death	(n = 4)	(n = 2)				
Mean ± SD	18,417 ± 9,572	7,337 ± 3,651	0.21	$2,637	−$1,670 to $6,944	0.230
Composite death	(n = 9)	(n = 4)				
Mean ± SD	13,885 ± 8,165	9,566 ± 8,373	0.40	$5,788	$2,845 to $8,730	< 0.001

Data presented in U.S. dollars. *Added costs report regression coefficients from regression model with ACUTE patient age, gender, cardiac death, noncardiac death, major bleed, minor bleed, and CVA/TIA included in the respective equation. These added costs represent the incremental costs of adverse events to the overall mean costs for each patient in both groups. †One patient had both major and minor bleeds.

CI = confidence interval; CVA = cerebrovascular accident; TEE = transesophageal echocardiography; TIA = transient ischemic attack; UNK = unknown.

$269; p = 0.50). Similarly, the bootstrapping results indicated no significant difference between groups (mean difference of $386; p = 0.50). In the overall model, an extended length of stay typically contributes significantly to increased hospital costs, but there was no significant difference in length of stay between the TEE-guided and conventional groups (p = 0.34, Wilcoxin).

Patient care costs of adverse events. Table 3 presents the mean patient costs associated with adverse events between the TEE-guided and conventional groups in the ACUTE trial from enrollment to eight-week follow-up. These costs are based on the converted hospital charge information previously described in Table 2. The added costs represent the incremental costs of adverse events to the overall mean costs and were derived using multiple regression (Table 3). The 95% confidence intervals, using regression coefficients including age, gender, death (both cardiac- and noncardiac-related), bleeding (both major and minor), and cerebrovascular accident/transient ischemic attack are also shown.

For each adverse event, there were no significant differences between the TEE and the conventional groups in mean patient costs with similar adverse events. Based on the incidence of major and minor bleeding and the hospital cost associated with bleeding, the cumulative total hospital cost was 24% higher for the conventional group compared to the TEE-guided group. Regression analysis showed that major bleeding added $16,285 to the overall mean cost of $6,374 for each patient in both groups as noted in Table 2. Thus, attempts to reduce the incidence of bleeding should have a positive economic impact as well as clinical benefit to affected patients.

Analytic model of treatment and outcome costs. Tables 4 to 6 show total treatment costs per patient in the TEE-guided group versus the conventional group using the second economic approach—the analytic model. This was used to validate the results of the ACUTE economic substudy. The overall treatment costs were somewhat lower than those found in the first economic approach (hospital charge data), but the resulting trend was similar. The net cost per patient demonstrated little difference ($79.57) between the TEE-guided and the conventional groups.

Sensitivity analysis of the analytic model. Sensitivity analysis showed that major bleeding (Fig. 2A) and the cost of the TEE (Fig. 2B) had the greatest impact on cost differences. Complete sensitivity analysis for the incidence and costs of stroke, death, and minor bleeding can be found in the online-only Appendix of this paper at www.cardiosource.com/jacc.html. Doubling the incidence of major bleeding in both treatment groups (to 2.4% and 3.9% in TEE-guided and conventional groups, respectively) resulted in overall savings using the TEE treatment as opposed to conventional treatment once the cost of a major bleeding event was in excess of $20,500 per event (Fig. 2A). Maintaining event incidence but varying the cost of TEE did not result in savings until the cost of the TEE was reduced from $277 to $185 (Fig. 2B). Conversely, increasing the cost of the TEE from $277 to $1,000 resulted in the TEE-guided group costing 17% more than the conventionally treated group ($4,166 vs. $3,446). Overall, using sensitivity analysis, cost differences varied from $896 in savings to $1,610 in additional costs for the TEE strategy.

DISCUSSION

The results of the economic analysis of the ACUTE trial show that in 833 randomized U.S. patients there is little difference in total patient costs over an eight-week period between the TEE-guided and the conventional groups.

Table 4. ACUTE Trial Analytic Model of Treatment Costs Using ACUTE Trial Data on 833 Patients

	TEE-Guided Strategy (n = 420)					Conventional-Guided Strategy (n = 413)		
Treatment	**Unit Cost**	**TEE #**	**Frequency**	**Total Costs**	**Conv #**	**Frequency**	**Total Costs**	**Reference**
TTE	$213.68	378	1.0	$80,771.04	370	1.0	$79,061.60	2000 Medicare reimbursement
TEE	$277.16	363	1.0	$100,609.08	13	1.0	$3,603.08	2000 Medicare reimbursement
Repeat TEE	$277.16	22	1.0	$6,097.52	0	1.0	$0.00	2000 Medicare reimbursement
Hospitalization	$486.75	308	5.5	$824,554.50	295	5.7	$818,470.13	CCF cost/charge 2000
aPTT	$21.50	210	5.0	$22,575.00	170	5.0	$18,275.00	CCF cost/charge 2000
Warfarin	$0.70	420	32.0	$9,408.00	413	56.0	$16,189.60	CCF cost/charge 2000
PT/INR tests	$10.40	420	4.6	$20,092.80	413	9.0	$38,656.80	CCF cost/charge 2000
DCC	$146.08	305	1.0	$44,554.40	198	1.0	$28,923.84	CCF cost/charge 2000
Gross total				$1,108,662.34	Gross total		$1,003,180.05	
Per patient cost				$2,639.67	Per patient cost		$2,429.01	

aPTT = activated partial thromboplastin time; Conv = conventional; CCF = The Cleveland Clinic Foundation; DCC = direct current cardioversion; PT/INR = prothrombin time/international normalized ratio; TEE = transesophageal echocardiogram; TTE = transthoracic echocardiography.

Table 5. ACUTE Trial Analytic Model of Outcomes Costs Using ACUTE Trial Results on 833 Patients

Outcome	Unit Cost	Multiplier	Frequency	Per Patient Cost	Multiplier	Frequency	Per Patient Cost	Reference
CVA	$28.212	0.00952	4	$268.58	0.00484	2	$136.55	Seto (12) 2000 discounted
TIA	$5.458	0.00238	1	$12.99	0.00242	1	$13.21	Seto (12) 2000 discounted
Minor bleed	$3.901	0.01666	7	$64.99	0.04840	20	$188.81	Seto (12) 2000 discounted
Major bleed	$30.188	0.01190	5	$359.24	0.01937	8	$584.74	Seto (12) 2000 discounted
Death	$7.355	0.02143	9	$157.62	0.00968	4	$71.20	Seto (12) 2000 discounted
Total per patient outcome cost				$863.42	Total per patient outcome cost		$994.51	

CVA = cardiovascular accident; TIA = transient ischemic attack.

Table 6. ACUTE Trial Analytic Model Summary

TEE treatment per patient	$2,639.67	Conventional treatment per patient	$2,429.01
TEE outcomes per patient	$863.42	Conventional outcomes per patient	$994.51
Total TEE-guided costs per patient	$3,503.09	Total conventional cost per patient	$3,423.52
Difference in total costs		$79.57	
Percent difference		2.27%	

TEE =transesophageal echocardiography.

Major cost-related variables that are linked to the different strategies include the cost of treatment, length of stay, and cost of treating adverse events. In this study, the cost of the TEE procedure added to the treatment costs of the TEE-guided strategy as might be expected. However, the cumulative costs of treating adverse events were found to be higher in the conventional group, driven by the higher bleeding rate for conventional patients with prolonged anticoagulation (21).

In summary, over an eight-week period, the cost of a TEE-guided strategy showed no significant difference from the conventional strategy. Using mean costs ($269) or using bootstrap results ($386), the TEE-guided approach was slightly more costly. Conversely, the difference in overall costs between the two strategies amounted to <5% of the total hospital and physician costs, which might not be considered economically significant.

Our study evaluated eight-week hospital and physician mean costs that were derived from hospital and physician total charges using hospital cost/charges (11,15). This "activity-based" method uses the more traditional "top-down" accounting methodology including charge-to-cost conversion (22). The benefit of this approach is that it may be more adaptable to other U.S. hospital settings. However, it does not detail individual costs as with a "microcosting" approach. As such, it can be more difficult to identify in detail the major contributors to overall cost. We used regression analysis to estimate the effects of different parameters on cost including adverse events. However, we felt it wise to introduce a completely separate "analytic" costing approach to validate the results of our "top-down" costing strategy. The analytic model did not incorporate every possible resource used, but it did detail a number of costs related to the treatment of patients in the TEE-guided and conventionally treated groups of the ACUTE study in a microcosting fashion. The actual incidence of resource usage was based on the ACUTE trial. However, the costs were derived from a number of published sources. The analytic approach allowed testing in the form of sensitivity analysis, a standard approach in economic analysis to investigate the potential cost differences (i.e., cost "drivers") in varying healthcare settings. The analytic model showed overall lower costs than those found in the ACUTE economic substudy. However, its message was the same, reflecting and supporting our primary cost analysis using hospital and physician charge data. There were little overall cost differences ($80) between the treatment strategies.

Sensitivity analysis. In addition, increasing the incidence and cost of major bleeding, as well as the cost of TEE, has the most extensive impact on cost differences between the TEE-guided and conventionally treated groups. However, the sensitivity analysis had little overall impact on the economic consequences of using the TEE-guided strategy as opposed to conventional strategy.

Cost-effectiveness model. Seto et al. (12) evaluated the cost effectiveness of the two approaches in hospitalized patients with recent onset AF, using a decision analytic model. Costs per quality-adjusted life year (QALY) were compared for three strategies: TEE-guided alone, TTE/TEE-guided, and conventional approaches. The authors concluded that the TEE-guided approach without TTE had a lower total cost and higher effectiveness ($2,774 per 8.49 QALY) compared with the TTE/TEE-guided approach ($3,106 per 8.48 QALY) and the conventional approach ($3,070 per 8.48 QALY). Thus, the TEE-guided approach was considered to dominate over the other two strategies. In this study, many assumptions based on a range of published sources were used for event probabilities and costs.

Our group developed a similar, albeit more basic, decision cost-effectiveness model (see Appendix for method and comprehensive results). This decision tree analysis used event probabilities and costs derived from the ACUTE trial. The decision tree model showed that the TEE-guided strategy was more costly by $185 when all treatment and outcome data were factored ($7,090 vs. $6,905). This cost-effectiveness model was developed for the eight-week study period only, unlike the Seto et al. (12) model, which included long-term survival. In our model, the conventional strategy dominated the TEE-guided strategy due to the higher incidence of death in the TEE group (which was not the case in Seto et al.'s model). However, the probability of death was not statistically different between the two strategies, and, when during sensitivity analysis, death was eliminated from the model, the TEE-guided group showed an incremental cost-effectiveness ratio (ICER) of $15,455 per QALY. An ICER of <$50,000 per QALY is considered a cost-effective approach for life saving interventions. Thus, the TEE-guided strategy would be considered a cost-effective alternative to the conventional strategy (23). If long-term follow-up were factored, it is likely that the TEE approach would prove even more cost-effective.

The incidence of stroke, major and minor bleeding, and death were higher in the Seto et al. (12) model than those found in the ACUTE study. The Seto et al. (12) costs for

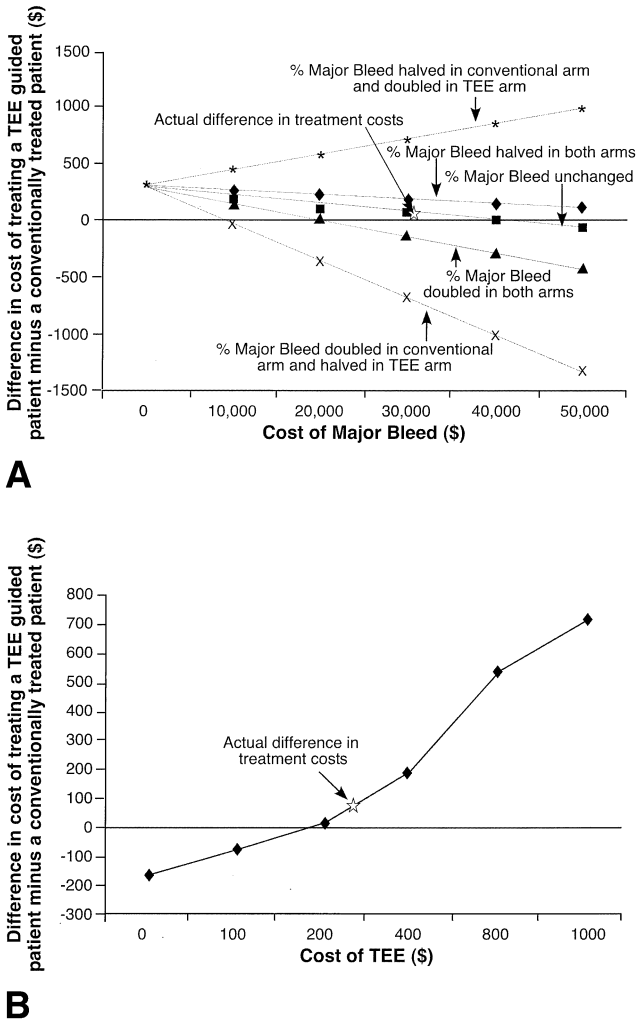

Figure 2. Sensitivity of the effect of varying the incidence and the cost of a major bleeding event **(A)** on the difference in the treatment costs between a transesophageal echocardiography (TEE)-guided and conventionally treated patient for the analytic model; effect of varying the cost of TEE on the difference in treatment costs **(B)** (including adverse events) between a TEE-guided and conventionally treated patient for the analytic model. The y axis shows the difference in cost of treating a TEE-guided patient minus a conventionally treated patient in dollars. The x axis shows the cost of the clinical event or TEE. Above the 0 baseline is more costly for TEE, and below the baseline is less costly for TEE. The **star** points to the actual difference in treatment costs.

TEE were greater, but those of minor bleeding were less than those found in our study. Costs of stroke and major bleeding were similar in both studies. These differences, combined with the fact that Seto et al. incorporated long-term follow-up, would explain why their model was more cost-effective than the one generated by our group. Further investigation would be required to generate the true long-term consequences of the different strategies for treating patients with AF.

Clinical implications. Atrial fibrillation is a very costly public health problem which imposes a large economic burden on health care (24). The results of our economic study show that a TEE-guided approach is only slightly more costly than the conventional approach, although outcome costs tended to be higher for the conventional strategy, resulting in no significant cost difference between the two strategies. The cost of the TEE procedure itself ($277 using Medicare reimbursement) is a relatively small portion of the $6,400 total eight-week management cost for patients undergoing cardioversion for AF. Therefore, this is an economically feasible alternative to conventional therapy. In the current era of rate control and prolonged anticoagulation (25), what then is the role of the TEE-guided approach to cardioversion? In clinical practice, the choice of the approach should be individualized to each AF patient. The TEE-guided approach is useful for the symptomatic young patient with new onset AF, for patients at high risk for stroke and bleeding, and for hospitalized patients in whom the TEE can help stratify patients by the detection of LAA thrombus, spontaneous echo contrast, and complex atheroma (26,27). In patients who are unlikely to have spontaneous conversion, the TEE-guided approach should be considered as well (28). Economic factors alone should not determine the choice of strategies to cardioversion.

ACUTE II study. Recently, our group has proposed the use of short-term low-molecular-weight heparin as a bridge to therapeutic warfarin therapy and TEE-guided cardioversion in the on-going ACUTE II study. This bridging approach has the potential to lower costs by treating patients as outpatients instead of in-patients and to increase patient convenience and quality of life compared with the use of intravenous heparin (29). The TEE-guided approach with low molecular weight heparin (Enoxaparin) may be the preferred approach as shown recently in the Anticoagulation in Cardioversion Using Enoxaparin (ACE) trial (30).

Study limitations. There are several limitations of the ACUTE economic substudy. Only U.S. clinical centers were used for analysis, and they may represent different clinical costs than non-U.S. sites. The marked variability in charges from hospital to hospital and among individual patients provides a considerable challenge in healthcare cost analysis. A number of techniques were introduced to try to manage these issues.

In addition, due to the sensitivity of publishing hospital cost data, data collection for economic studies is often difficult. Cost data for 44% of our U.S. patient population were unable to be collected. The data for these patients were imputed based on the data collected for the other patients enrolled in U.S. hospitals. It was recognized that this resulted in the use of cost estimates, and, thus, there was a need to validate our findings with an analytic model.

Finally, we used UB-92s to calculate costs. This may be limited because it does not include patient self-reporting of office visits, home health services, rehabilitation, and use of medication. Therefore, our outpatient or follow-up costs may underestimate the true healthcare costs of these patients.

Conclusions. In patients with AF >2 days' duration undergoing electrical cardioversion, the TEE-guided group showed little difference in patient costs compared with the

conventional group. The TEE strategy had higher initial treatment costs but lower outcome-associated costs. Cumulative costs were 24% higher in the conventional group, primarily due to bleeding and hospital costs associated with bleeding. The TEE-guided strategy is an economically feasible approach compared with the conventional strategy.

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APPENDIX

For the complete Appendix, please see the April 7, 2004, issue of *JACC* at www.cardiosource.com/jacc.html.