A cost-minimization analysis of dexmedetomidine compared with midazolam for long-term sedation in the intensive care unit*

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Objective: **To compare the intensive care unit costs and determine factors influencing these costs in mechanically ventilated patients randomized to dexmedetomidine or midazolam by continuous infusion.**

Design: **Cost minimization analysis of a double-blind, multicenter clinical trial randomizing patients 2:1 to receive dexmedetomidine or midazolam from the institutional perspective.**

Setting: **Sixty-eight intensive care units in the United States, Australia, New Zealand, Brazil, and Argentina.**

Patients: **A total of 366 intubated intensive care unit patients anticipated to require sedation for >24 hrs.**

Measurements and Main Results: **Intensive care unit resource use was compared within the two treatment arms, using the U.S. representative costs for these resources. The analyses characterized patient costs from start of study drug until intensive care unit discharge including costs associated with the intensive care unit stay, costs during mechanical ventilation, study drug acquisition cost, and costs of treating adverse drug reactions probably or possibly related to study drugs. Blinded to treatment group, costs were calculated using Medicare reimbursement schedules, average IMS drug costs, expert opinion, and peer-reviewed literature. Censored lengths of intensive care unit stay and mechanical ventilation were imputed, using a nonparametric adjustment algorithm. Crude and multivariate median regressions were performed to relate intensive care unit cost and treatment. Including drug acquisition cost, sedation with dexmedetomidine was associated with a median total intensive care unit cost savings of $9679 (confidence interval, $2314–$17,045) compared with midazolam. The primary cost drivers were reduced costs of intensive care unit stay (median savings, $6584, 95% confidence interval, $727–$12,440) and reduced costs of mechanical ventilation (median savings, $2958, 95% confidence interval, $698–$5219).**

Conclusions: **Continuous sedation with dexmedetomidine results in significantly lower total intensive care unit costs compared with midazolam infusion for intensive care unit sedation, primarily due to decreased intensive care unit stay costs and reduced mechanical ventilation costs. (Crit Care Med 2010; 38: 497–503)**

KEY WORDS: sedation; dexmedetomidine; midazolam; pharmacoeconomics; costs; outcomes

Providing sedation and analgesia to intensive care unit (ICU) patients is necessary to ensure patient comfort and well-being (1). However, these agents can cause adverse drug reactions (2, 3). Although critically ill patients have diverse conditions and rapidly changing disease severity, optimizing sedation and analgesia can improve clinical outcomes and reduce healthcare costs (4, 5).

Given the high costs of ICU care (from $3500–$8000 per day) and incremental costs of mechanical ventilation ($1500 per day), interventions that decrease length of ICU stay or reduce time on mechanical ventilation can significantly reduce ICU costs (6). Despite abundant clinical research, there are few economic analyses comparing sedatives in the setting of contemporary critical care (7, 8).

Originally approved for use up to 24 hrs, dexmedetomidine is an α_2-agonist with sedative, sympatholytic, and analgesic-sparing properties, with a favorable safety profile compared with benzodiazepines and propofol (9). Recent data suggested that dexmedetomidine may be administered safely beyond 24 hrs in the ICU and in dosages up to 1.4 μg/kg/hr (10, 11). The Safety and Efficacy of Dexmedetomidine Compared With Midazolam Study Group (SEDCOM) study, a double-blind multicenter trial randomized 375 mechanically ventilated ICU patients to receive dexmedetomidine or midazolam infusions (12). Patients treated with dexmedetomidine experienced a lower frequency rate and shorter duration of delirium, fewer infections, a lower rate of tachycardia and hypertension requiring treatment, a shorter time to ex-

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tubation, but higher rates of bradycardia and hyperglycemia.

This study is a nested pharmacoeconomic evaluation of SEDCOM data with the primary goal to determine the total ICU cost difference between patients sedated with dexmedetomidine compared with midazolam. Secondary research questions measured hypothesized cost drivers including cost of ICU stay, cost of mechanical ventilation, study drug acquisition cost, and cost of treating adverse drug reactions.

MATERIALS AND METHODS

Economic Evaluation

This is a secondary analysis of the previously published SEDCOM study and the protocol was approved by the Institutional Review Board of the study centers, and all patients or legally authorized representatives provided their written informed consent in this prospective study (12). The primary outcome in SEDCOM, the percent time patients were maintained in the target sedation range, was similar for patients receiving dexmedetomidine (77%) or midazolam (75%) (12). As such, a cost-minimization analysis was performed, from the institutional or provider perspective (13). We analyzed ICU cost difference in patients post randomization to dexmedetomidine or midazolam for ICU sedation.

Costing Methods and Sources

Investigators were blinded to the treatment group for all cost analyses. Total post randomization ICU cost was calculated for each treatment group by including the following components: cost of ICU stay; cost of mechanical ventilation; cost of treating adverse drug reactions probably or possibly related to the study drug; and cost of study medication. Actual patient resource use was converted, using a constant estimated cost value for each component. Dasta et al previously determined costs in three types of ICUs from claims data, using a geographically diverse sample of 51,000 patients from approximately 300 general medical/surgical hospitals in the United States, identifying the high-, middle-, and low-cost ICUs. The costs of ICU stay and mechanical ventilation were calculated by multiplying the number of hours spent in the ICU from the start of study drug by published hourly costs, using the middle-level ICU cost (6). The costs for nonmechanically ventilated patients and the incremental cost of mechanical ventilation were calculated individually and converted to 2007 US dollars, using the medical care consumer price index (14).

The ICU cost was calculated taking into account delay from ICU admission to start of study drug. For example, if the patient spent 24 hrs in the ICU before start of the study drug, the ICU cost was calculated beginning with the day 2 hourly cost (6). Hourly ICU costs were determined by dividing the daily ICU costs in nonventilated ICU patients by 24 hrs/day, yielding the following hourly costs: day 1: $406/hour, day 2: $203/hour, day 3 and beyond: $184/hour (6). The hourly incremental mechanical ventilation cost was determined in a similar manner, yielding an hourly cost of $80 (6).

The cost of study medication was determined, using IMS pricing for drug costs (2007 yr to date average sales price) (15). The dexmedetomidine cost was $58.31 per 200-μg vial, and the midazolam cost was $1.56 per 5-mg vial. Only costs for whole vials were used to account for drug wastage.

The cost of treating adverse drug reactions, considered by the site primary investigator, to be probably or possibly related to the study drug (12), was estimated by expert physicians and pharmacists. Examples include bradycardia, tachycardia, hypotension, oversedation, and undersedation as well as cost of other adverse drug reactions identified *a priori* as possibly or probably related to study drug in the clinical trial. Cost of adverse drug reaction management included diagnostic tests, procedures, consultations, and treatments usually performed. Costs were obtained from Current Procedural Technology codes (16) for tests, procedures, and consultations and from the Bureau of Labor Statistics (17, 18) or wages (2007 US dollars.) The detailed cost dictionary appears in the Appendix. The probability of each test, procedure, or consultation being performed was assigned independently by three of the authors (S.L.K.-G., R.R.R., P.M.B.) and averaged. The cost of each test, procedure, or consultation for each adverse drug reaction was multiplied by the probability of it being performed and then all costs for each adverse drug reaction were added to create a total expected value for each occurrence.

Statistical Analyses

All analyses were performed on the primary analysis population, i.e., all patients who received any amount of study drug. The total ICU cost was the primary outcome and was the sum of ICU cost per hour, mechanical ventilator cost per hour, cost of treating adverse drug reactions, and acquisition cost of study drugs. Potential total cost drivers including ICU cost and cost of mechanical ventilation were analyzed separately as secondary outcomes. One third of patients had their time to ICU discharge and time to extubation censored at the time of study drug discontinuation because ICU discharge time or extubation time was not available due to death or discontinuation of study drug for other reasons. Two strategies were used to estimate ICU and mechanical ventilation times for these censored patients. The first approach did not adjust data so the censored time was analyzed as actual time. This approach is conservative and underestimates the time in the ICU or on mechanical ventilator because these censored patients were in the ICU or on mechanical ventilator longer than the censored time. To address this issue, a nonparametric imputation method (19, 20) was used to impute ICU discharge or extubation time for those patients with censored times. A "null" regression of observed ICU times on a constant (mean) value was fit to obtain raw residuals for each subject: $r_I = Y_I - \beta_0$, where Y_i is the observed ICU (or mechanical ventilation) time in the subject i and β_0 is the mean ICU time in the study population. We then sorted the residuals in descending order and adjusted them recursively by taking an average of their value with all larger (adjusted) residuals. Values related to individuals whose times were not censored were left unchanged. Once all raw residuals had been converted to adjusted residuals, they were sorted back into their original order, and X_i, the imputed ICU (or mechanical ventilation) time, was calculated as $X_i = Y_i - r_i + r^*_i$, where r^*_i denotes the adjusted residual. Analyses using this approach were *a priori* deemed primary.

Before analysis, visual inspection of the outcome distribution was performed, using box plots. Based on Tukey's fences, outliers were detected, suggesting that standard linear regression may be inappropriate (21). Hence, a median regression approach was adopted which is analogous to linear regression with medians instead of means being modeled. Quadratic loss function (used for minimization) is replaced by absolute value loss function (22, 23).

All models were first run with treatment indicator (midazolam arm used as referent) without covariates (crude) and then adjusting for potential confounders including patient age, sex, baseline Acute Physiology and Chronic Health Evaluation II score as well as race and hospital characteristics (location: U.S. vs. non-U.S., size: number of beds, teaching status, and type: urban vs. rural).

A sensitivity analysis was performed on our ICU cost assumptions per hour as it represents the largest component of the total ICU cost difference. We performed this analysis to assess the robustness of our findings relative to the choice of imputation method and methods of cost assignment. Thus, we repeated all analyses separately by taking the high-cost and low-cost ICUs from the paper by Dasta et al (6) and converted costs to 2007 dollars. The hourly costs were: high-cost ICU (day 1: $481/hour, day 2: $212/hour, day 3 and beyond: $184/hour) and low-cost ICU (day 1: $208/hour, day 2: $177/hour, day 3 and beyond: $157/hour).

Table 1. Median (1st–3rd quartile) costs[a] between study arms

Cost Driver	Dexmedetomidine (n = 244), $	Midazolam (n = 122), $	p^b
Nonparametric censoring method			
Total ICU cost	40,365 (27,557–60,971)	50,149 (32,730–71,861)	.010
ICU component	36,571 (21,017–45,010)	40,501 (25,063–51,206)	.028
Mechanical ventilation component	7022 (3,293–12,762)	10,885 (5257–16,790)	.010
Adverse drug reaction treatment component	507 (175–1167)	810 (265–1694)	.013
Unadjusted method			
Total ICU cost	27,694 (17,577–46,756)	34,122 (21,818–58,604)	.025
ICU component	20,178 (12,128–32,286)	25,618 (16,563–41,720)	.026
Mechanical ventilation component	5541 (2622–9145)	7293 (3598–11,274)	.040
Adverse drug reaction treatment component	507 (175–1167)	810 (265–1694)	.013

ICU, intensive care unit.

[a]Regression analysis on acquisition cost of study drugs was not performed because it was not an outcome variable and there was a 20-fold difference in costs; median cost dexmedetomidine $1,166 vs. midazolam $60; [b]the p value based on median regression models for each cost driver, comparing dexmedetomidine with midazolam, with patient age, sex, and Acute Physiology and Chronic Health Evaluation II score in the model, controlling for patient race, hospital type, size, geographical location, and teaching status.

Table 2. Median regression model of primary outcome[a]—total intensive care unit cost with nonparametric imputation (n = 366)

Variable[b]	Regression Coefficient	95% Confidence Interval	p
Dexmedetomidine	−9679	−17045, −2314	.010
Age	258	20, 497	.034
Male gender	−1758	−8694, 5178	.618
APACHE II score	505	−29, 1038	.064

APACHE, Acute Physiology and Chronic Health Evaluation.

[a]Model controlling for patient race, hospital type, size, geographical location, and teaching status; [b]the term "regression coefficient" refers to median regression and corresponds to the adjusted median cost difference. For continuous variables, regression coefficient represents a median cost increase per one unit change (1 yr for age and 1 point for APACHE II within the range of values in this study).

All analyses were performed in STATA version 10 and a two-sided $p < .05$ was considered statistically significant (24).

RESULTS

Baseline patient characteristics and clinical findings in patients randomized to the treatment groups were previously reported (12). The unadjusted median total ICU cost was significantly lower for patients in the dexmedetomidine group ($27,694, $p = .025$) compared with $34,122 in the midazolam arm (Table 1). Median costs calculated after adjusting for censored ICU and ventilation times were about 50% higher in each group, and remained significantly lower in the dexmedetomidine arm.

In the primary analysis, adjusted for covariates and censoring patients, the dexmedetomidine arm achieved a median cost saving of $9679 (95% confidence interval [CI], $2314–$17,045, $p = .01$) (Table 2). The corresponding estimate from the crude model (without covariates) was $9692 (95% CI, $896–$18,487, $p = .031$). When we did not account for censoring of the ICU and mechanical ventilation times, the estimated total ICU cost savings remained statistically significant but was less:$5066 (95% CI, $635–$9497, $p = .025$) for the covariate-adjusted model and $6917 (95% CI, $2192–$11,643, $p = .004$) for the crude model. In the primary model, the only other significant predictor of total cost was patient age contributing a median increase of $258 (95% CI, $20–$497) per 1 yr of age.

Costs of ICU stay and mechanical ventilation were the main drivers of total ICU cost, accounting for 98.5% of the cost difference. Although a complex model was constructed to estimate costs of treating adverse drug reactions, it comprised only a small portion of the total ICU costs.

After adjusting for covariates and censoring patients, dexmedetomidine use resulted in significant median cost savings in both ICU ($6584, 95% CI, $727–$12,440) and mechanical ventilation ($2958, 95% CI, $698–$5219) component costs. The median component costs associated with treating adverse drug reactions were also significantly lower in the dexmedetomidine arm ($229, 95% CI, $49–$409, $p = .013$). These cost savings were observed despite higher study drug acquisition cost for dexmedetomidine (mean costs = $1826 vs. $80, median costs = $1166 vs. $60, respectively).

In the sensitivity analyses, the high-range ICU cost resulted in an adjusted median cost savings for dexmedetomidine estimated at $10,082 (95% CI, $2349–$17,814, $p = .011$) and low-range ICU cost yielded an adjusted median of $8951 (95% CI, $2467–$15,436, $p = .007$). The results obtained, using different statistical methods to account for censoring in times of ICU stay and mechanical ventilation, yielded results consistent with the nonparametric adjustment presented above (Table 1).

DISCUSSION

Our results demonstrate that total ICU costs, which include acquisition costs of study drugs, are lower in mechanically ventilated patients sedated with dexmedetomidine compared with patients sedated with midazolam. The primary drivers of total ICU cost savings are reduced costs associated with ICU stay and costs of mechanical ventilation. This finding is important as it provides insight into the economic consequences of different clinical effects of these two sedatives studied in the setting of contemporary care of critically ill patients. It also provides additional information that may guide the decision-making process for selecting drug therapies for ICU sedation both at the bedside and at the healthcare system level as part of Formulary review.

Cost-effectiveness is the most common form of economic analysis in health care and uses the ratio of incremental change in cost to the incremental change in effectiveness (25, 26). However, in studies where there is no difference in primary outcome, a cost-effectiveness analysis cannot be performed because the denominator in this ratio would approach

zero (13). Given the similar percentage of time at target sedation range as the primary outcome of SEDCOM, we performed a cost-minimization analysis on ICU sedation, an area where relatively few pharmacoeconomic evaluations have been conducted (7). Studies often report differences in drug acquisition cost, not considering differences in effectiveness or safety (27, 28). These studies have a limited impact on our understanding of pharmacoeconomics because they do not incorporate the downstream cost of care associated with different therapies (7).

Drug acquisition cost is only one factor in assessing the total cost of therapy (29). More expensive drugs can have economic benefit resulting from their pharmacologic properties, such as shorter duration of action, lack of accumulation, fewer adverse drug events, or less potential for prolonged time on the mechanical ventilator. A recent study used a decision model to determine the cost-effectiveness of sedatives (8). The base-case analysis used the findings of a clinical trial of mechanically ventilated ICU patients randomized to intermittent lorazepam or propofol with daily awakening in both arms. Efficacy was defined as mechanical ventilator-free days and mechanical ventilator-free survival, up to 28 days after intubation. Despite an approximately tenfold higher drug acquisition cost, propofol was the most cost-effective regimen compared with lorazepam. Another cost study analyzed retrospectively claims data from two cohorts of cardiac surgery patients; 9996 patients treated with midazolam and propofol were compared with 356 patients treated with dexmedetomidine in addition to midazolam and propofol (30). Despite total pharmacy charges that were approximately $4,000 higher in the dexmedetomidine cohort, total hospital charges were significantly lower by $17,790. The reduction in ICU charges accounted for 84% of this cost difference, consistent with our results obtained within a randomized trial.

The present study goes beyond evaluating only drug acquisition costs, assessing differences in the total cost of ICU care between the two treatment groups based on actual resource use. It was important to include an assessment of the costs of treating adverse drug reactions as part of total ICU costs because cost minimization studies frequently exclude these costs. However, drug acquisition costs and costs of treating adverse drug reactions accounted for only 2% of the difference in total ICU cost. This emphasizes the potential economic impact of therapies that reduce time in the ICU and shorten mechanical ventilator time. Although the ICU length of stay was not statistically different between treatment groups in SEDCOM (12), the cost associated with ICU stay was significantly different and was a major driver of the reduced total ICU cost. This apparent discrepancy can be explained by the different statistical analyses involved. SEDCOM used unadjusted time to event survival analysis (which focuses on the number of binary events) with a very conservative Bonferroni correction for multiple variables assessed, whereas the current study uses median regression (adjusted for other contributing factors) of the continuous variable, cost. As such, the evidence confirms that total ICU costs are less with dexmedetomidine.

Only one pharmacoeconomic study of ICU sedation to date (7) has performed a sensitivity analysis (8). Given that any cost model is based on assumptions, a sensitivity analysis allows us to estimate how our results change with higher or lower assumptions. Because ICU component costs accounted for the majority of the cost difference, we performed a sensitivity analysis by using the range of ICU costs based on the type of ICU, as reported previously (6). The cost savings associated with dexmedetomidine remained statistically significant in the highest and lowest costs. An additional strength of this study was that the authors were blinded to the treatment group when the cost analysis was performed, thus minimizing bias. The lower total ICU costs associated with lower component ICU and mechanical ventilation costs may be explained by the pharmacologic differences between the two medications (12). Unlike midazolam, dexmedetomidine does not cause respiratory depression, which may facilitate quicker extubation (11). Also, patients receiving dexmedetomidine had a lower frequency rate and shorter duration of delirium (12). Delirum is partly mediated by stimulation of the gamma amino butyric acid (GABA) receptor (31). Because dexmedetomidine is an α-$_2$ receptor agonist, it does not have activity at GABA receptors. A higher prevalence of delirium with GABA mimetic drugs like midazolam therefore might be expected, and has been shown in other studies as well (32, 33). In addition, it has been reported that mechanically ventilated medical ICU patients, who experience delirium, have longer ICU and total hospital stays with corresponding costs 1.4- and 1.3-fold higher than patients who never develop delirium (34). The present study did not separate the cost of delirium, but it was embedded in the cost of ICU stay and likely contributed to longer time on the ventilator and in the ICU, and associated increased costs in patients receiving midazolam.

Several limitations of our study deserve comment. SEDCOM patients were required to receive continuous infusions of sedating medications, and recorded clinical trial data from centers in the United States and four other countries as a pooled data set. Data from one country may not apply to others. However, countries other than the United States provided approximately 20% of the total patients analyzed. The protocol specified maintaining a lighter level of sedation (target Richmond Agitation Sedation Scale –2 to +1), avoiding coma (Richmond Agitation Sedation Scale –4, –5), using a daily arousal assessment, and performed daily respiratory function assessments, but protocols for weaning from mechanical ventilation were specific to each investigative site. As such, it is unclear how our cost data would be affected by a standardized weaning protocol.

This cost analysis was limited to the time from randomization of study drug to ICU discharge, or death, representing the time when the study protocol controlled sedation. Additionally, nearly a third of patients died or had study drug discontinued before extubation and their data regarding ICU length of stay and duration of mechanical ventilation were censored at that time. Sophisticated statistical techniques comparing different imputational strategies to account for censored data confirmed that the results remain robust. Actual patient resource use was used to calculate the major components of the model (ICU length of stay, ventilator duration, drug doses).

Hospital bills (which were available for a minority of study patients) include charges before and after study control, and the cost/charge ratio varies significantly between hospitals, which may confound efforts to estimate true costs. Instead, we estimated costs of mechanical ventilation and ICU stay based on actual patient resource use multiplied by the same published ICU daily costs converted to an hourly rate as a function of the duration of ICU stay (6). Those daily costs did not include all fixed costs, such as salary and wages, but the UB-92 bill used in that study (6) included all relevant

costs, and were averaged from >50,000 patients. Fixed costs (such as salaries) should be equal in the two study arms at any given center, reducing potential bias with the randomized trial design. Expert opinions were used to estimate the specific tests and treatments for adverse drug reactions. Although important considerations, these costs were trivial in comparison to the much larger costs for ICU and ventilatory therapy. Finally, this study was not conducted from the societal perspective (which incorporates lost wages, rehabilitation costs, etc.) but from the institutional perspective, which estimates more directly reimbursement and related profit-loss estimates for hospitals that care for critically ill patients (26).

CONCLUSIONS

Dexmedetomidine-based sedation for ICU patients was significantly less costly than continuous infusion midazolam. The reduction in total ICU costs can be explained primarily by decreased costs associated with reduced mechanical ventilation duration and ICU length of stay. The α_2-agonist dexmedetomidine provides pharmacologic and economic advantages compared with midazolam for mechanically ventilated ICU patients requiring sedation.

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Appendix. Cost dictionary used to estimate cost of treating adverse drug reactions possibly or probably related to study drugs

Name of Service	CPT Code, if Applicable	Cost in 2007 U.S. Dollars[a]	Reference
ICU stay, day 1		$405.99/hr	6
ICU stay, day 2		$203.41/hr	6
ICU stay, day 3 and on		$184.29/hr	6
Mechanical ventilation		$79.96/hr	6
Dexmedetomidine		$58.31/vial	15
Midazolam		$1.56/vial	15
Reintubation	31500	$121.45	16, 35
Restraint kit		$243.57	37
Physician consultation, mild adverse event	99253	$96.55	16, 35
Physician consultation, moderate adverse event	99254	$132.89	16, 35
Physician consultation, severe adverse event	99255	$180.32	16, 35
Psychiatrist consultation	90819	$96.22	16, 35
12-lead ECG	93307	$200.51	16, 35
Abdominal ultrasound	76700	$108.66	16, 35
Administer IV fluids	90780	$38.35	16, 35
Administer blood/plasma	36430	$34.65	16, 35
Angiographic techniques for source of bleeding	71275	$92.09	16, 35
Arterial blood gas	82803	$31.29	16, 35
Blood chemistry	85025	$12.78	16, 35
Blood count, platelet only	85049	$4.37	16, 35
Blood culture	87040	$10.77	16, 35
Blood draw	85025	$12.78	16, 35
Bronchoscopy	31622	$209.25	16, 35
BUN	84520	$7.06	16, 35
Cardiac pacing	92953	$21.19	16, 35
Cardiac ultrasound	76604	$73.00	16, 35
Cardioversion	92960	$144.33	16, 35
CBC count	85025	$12.78	16, 35
Central catheter replacement	36580	$258.61	16, 35
Chest radiography	71030	$42.73	16, 35
Coagulation studies	85345	$7.06	16, 35
Coronary artery bypass	33533	$2005.08	16, 35
CPK isoenzymes	82550	$9.76	16, 35
Creatinine	82565	$7.74	16, 35
CT scan, chest	71250	$260.39	16, 35
CT scan, brain	70450	$204.54	16, 35
Drug screen	80100	$22.54	16, 35
ECG	93000	$26.91	16, 35
Echocardiography	93312	$255.68	16, 35
EEG	95812	$103.62	16, 35
Electrolyte replacement	90780	$38.35	16, 35
Electrolyte testing	80051	$15.81	16, 35
Electrophysiologist, per hour		$39.96	17
Electrophysiology studies	93609	$570.91	16, 35
Electrophysiology studies	93613	$371.77	16, 35
Endoscopic investigation for source of bleeding	32654	$873.35	16, 35
Extracorporeal membrane oxygenator	36822	$396.64	16, 35
Eye drops		$10.33	36
Fibrin degeneration products	85378	$11.44	16, 35
Fibrinogen I activity	85374	$14.13	16, 35
Glucose	82947	$6.39	16, 35
Hepatitis panel	86704, 86705, 86706, 86707, 86708, 86709, 86803	$128.18	16, 35
Incision ablation	33255	$1573.13	16, 35
Internal cardioversion	92961	$250.5	16, 35
IV reinsertion	90765	$75.04	16, 35
KUB with lateral chest			16, 35
Laryngoscopy	31505	$36.67	16, 35
Liver function tests	80058	$11.44	16, 35
Lumbar puncture	62282	$149.04	16, 35
Magnesium	80051	$9.08	16, 35
Magnetic resonance angiography	71555	$470.66	16, 35
MRI	71550	$463.59	16, 35

Appendix. —*Continued*

Name of Service	CPT Code, if Applicable	Cost in 2007 U.S. Dollars[a]	Reference
Multiple gated acquisition scans	78472	$38.19	16, 35
Myoglobin	83874	$15.48	16, 35
Neck or chest radiograph	70370	60.89	16, 35
Pulmonary function tests	94010	$30.28	16, 35
Radiography, KUB	74241	$86.46	16, 35
Respiratory therapist, per hour		$23.37	18
Serum chemistries	80051	$15.81	16, 35
Serum digoxin level	80162	$19.18	16, 35
Serum electrolyte and magnesium levels	80051	$15.81	16, 35
Serum iron, total iron bonding capacity, and serum ferritin	83540	$10.43	16, 35
Stent placement	92980	$1,089.34	16, 35
Thoracic CT scan	71250	$260.39	16, 35
Thrombolytic therapy	92975	$450.13	16, 35
Thromboplastin time	85610	$3.70	16, 35
Thyroid function	78011	$105.30	16, 35
Transcutaneous pacing	92953	$21.19	16, 35
Transesophageal echocardiogram	93312	$255.68	16, 35
Transthoracic echocardiogram	93307	200.51	16, 35
Transvenous pacing	33210	$231.12	16, 35
Troponin	84414	$17.75	16, 35
Urinalysis	81000	$4.37	16, 35
Urine culture	87086	$8.41	16, 35
Urine Gram-negative stain	87205	$6.39	16, 35
Ventilation/perfusion scan of lungs	78584	$159.80	16, 35
Radiograph, abdomen	74000	$26.91	16, 35

ECG, electrocardiogram; IV, intravenous; BUN, blood urea nitrogen; CBC, complete blood count; EEG, electroencephalogram; KUB, kidneys, ureters, and bladder; MRI, magnetic resonance imaging; CT, computed tomography.

[a]Costs were inflated to 2007 U.S. dollars, using the medical care consumer price index.