Using Delta/DRG Diagrams and Decision Tree Analysis to Select a Cost-Effective Surgery for Cholecystitis

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ABSTRACT

Background and Objectives: Many studies have attempted cost analysis of laparoscopic cholecystectomy as compared to open cholecystectomy. However, these analyses have included costs, charges, expenses, etc., and at times they have been used interchangeably. This paper demonstrates how DRG diagrams containing charges and length-of-stay, preoperative prediction of conversion rates, decision-tree construction and sensitivity analysis can be used to select the most cost-efficient operation for a given patient with cholecystitis.

Methods: A Delta DRG analysis for complicated cholecystectomy (DRG 195) showed the hospital to be an extreme outlier in both charges and length of stay. Record review indicated that 55% of the cases were converted laparoscopic cholecystectomies and the remainder were aged or younger patients with advanced disease. Chart and literature review determined the causes and the probability of conversion. Data were then placed into decision-tree and sensitivity analyses. The most cost-effective operation for a given probability of conversion was demonstrated.

Results: Three preoperative findings and combinations of each predicted conversion rates and analysis showed that the charge of laparoscopic cholecystectomy must be held below the range of $5,361 - $13,084 to make routine laparoscopic cholecystectomy cost-effective.

Conclusions: This method demonstrated that using Delta/DRG, decision-tree and sensitivity analysis offers physicians, hospitals and other health-care providers a method of evaluating the treatment of DRG categories to determine the most cost-effective management.

Key Words: DRG (diagnosis related group), Decision tree analysist.

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INTRODUCTION

Since the introduction of laparoscopic cholecystectomy, many attempts have been made to perform cost analysis of this procedure in comparison to open cholecystectomy.[1-11] Analyses have used terms like "expenses, costs, and charges" interchangeably, confusing definitions and accurate comparisons. Furthermore, critical analysis of the literature is made even more difficult because some studies include all patients and others examined only elective laparoscopic cholecystectomies. In addition, these studies were generated from various geographical/socioeconomic areas and represented variable payer mixes.

Most hospitals don't know their costs because a charge-accounting system is used instead of a cost-accounting system.[12] Cost data are usually generated by individuals or groups of individuals who are interested enough in a subject to procure the information base.

Charge data are generally available because law demands that hospitals submit these data to state and national databases for analysis. This is manifested in regional and national Diagnostic Related Groups (DRG) reports containing this information. These data are publicly available and compiled for analysis by various government and private organizations. Users, including managed care plans, analyze these data to compare hospitals for cost efficiency by various DRG categories.

This study demonstrates how DRG analysis of laparoscopic cholecystectomy may lead to further examination of data and produce cost-efficiencies in the treatment of cholecystitis. Following identification of the inefficiencies, Pareto analysis and subsequently decision-tree analysis were used to identify patient groups which should be treated by either open cholecystectomy or laparoscopic cholecystectomy.

METHOD

In 1994, several Delta/DRG diagrams were prepared for Maricopa Medical Center (MMC). A sample DRG 195 (cholecystectomy, with common duct exploration, with complications) **(Figure 1)** showed that MMC (HX in **Figure**

1) exceeded 16 other hospitals in both Length-Of-Stay (LOS) and charges. This prompted a review which determined that 55% of the cholecystectomies in this DRG category were converted laparoscopic cholecystectomies. Subsequent chart review showed that patients with the following preoperative findings showed higher conversion rates:

- Dilated common duct > 10 mm
- BMI (Body Mass Index) > 30
- Thickened gallbladder wall with sludge
- Severe right upper quadrant tenderness
- More than 24 hours of pre-operative pain
- Previous upper abdominal surgery

Hutchison, Traverso and Lee[13] analyzed 587 laparoscopic cholecystectomies and found some similarities. Their significant pre-operative findings predicting conversion were:

- Males = 13.8%
- Body Mass Index > 27 = 12%
- Common Bile Duct > 1 cm = 26%
- Thickened Gallbladder Wall = 33.3%
- Ultrasound Murphy's Sign = 33.3%

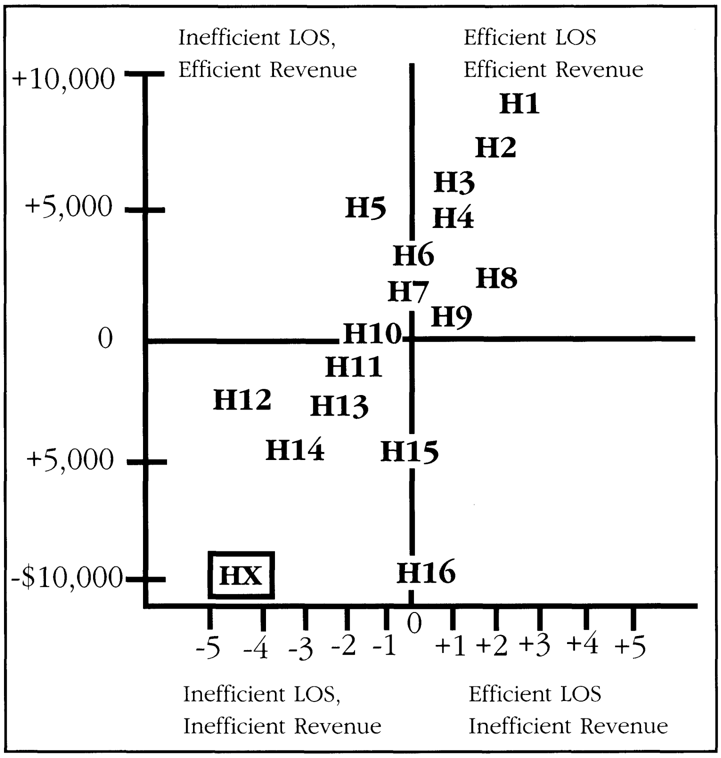

Figure 1. DRG 195.

RESULTS

Using Traverso's raw data, our analysis produced not only odds ratios for the three most significant factors predicting conversion, but the odds ratios and percentage of conversions for combinations of each of these factors **(Figure 2)**. For example, a thickened gallbladder wall and a body mass index > 27 produces an odds ratio of 9.52 (patient having these findings is 9.52 times more likely to have an open cholecystectomy than a patient with neither) and a 50% probability of conversion. A thickened gallbladder wall, a dilated common duct and a BMI > 27 produce an odds ratio of 12.14 and a conversion rate of 50%.

These data and decision-tree analysis produced predictions of cost-effective treatment. For example, decision-tree analysis on all probabilities of conversions demonstrated that laparoscopic cholecystectomy at MMC is not cost-effective, regardless of the risk of conversion **(Figures 3,5,7,9)**. Furthermore, if a prediction rate for conversion were 33%, a savings of $4,020 ($18,281 - $14,261) would be achieved if open cholecystectomy were done without consideration of laparoscopic cholecystectomy in the presence of a thickened GB wall by ultrasound **(Figure 3)**. However, sensitivity analysis **(Figure 4)** discloses that if the charge for laparoscopic cholecystectomy could be held under $10,010, the financial risk of possible conversion would be acceptable. A BMI > 27 yields a conversion rate of 12% **(Figure 5)** and a savings of $2,576 ($16,837 - $14,261) with routine open cholecystectomy. However, the sensitivity analysis showed that if laparoscopic cholecystectomy charges could be reduced to less than $13,084, routine laparoscopic cholecystectomy on this category of patients would be financially feasible **(Figure 6)**. The conversion rate for a dilated common duct > 1 cm **(Figure 7)** predicts a conversion of 26% and a savings of $3,539 ($17,800 - $14,261) with routine open cholecystectomy. The sensitivity analysis **(Figure 8)** shows that laparoscopic cholecystectomy charges would have to be reduced to < $11,228 before routine exploration by laparoscopy would be financially acceptable. If the conversion rate were 50% (i.e. BMI > 27 with a thickened gallbladder wall and a combination of all three significant preoperative findings) **(Figure 9)**, laparoscopic exploration would require a charge of <$5,631 before becoming cost-effective. Moreover, a savings of $5,190 ($19,451 - $14,261) would be realized with routine open cholecystectomy on all patients fitting these categories **(Figure 10)**.

In summary, depending on the probability of conversion for each of the predicting factors or combinations of the predicting factors, the laparoscopic charges must be held below $5,631 - $13,084 before routine laparoscopic cholecystectomy on these patients is cost-effective.

It must be noted that endoscopic sphincterotomy and ERCP

	Thickened GB Wall	Common Bile Duct Dilation	BMI>27
Thickened GB Wall	6.93x(33%)		
Common Bile Duct Dilation	9.54x(36%)	2.61x(26%)	
BMI>27	9.52x(50%)	5/20x(32%)	2.59x(12%)

TGBW+CBDD+BMI>27=12.13 (50%)

Figure 2. Traverso's data on 587 laparoscopic cholecystectomies.

charges are not a factor in this analysis because of the limited availability at our hospital and the premise that if stones are found on routine cholangiogram in a patient < 70, open common duct exploration will be done to expedite the patient's care and give the surgical residents experience in common duct exploration. This strategy obviously accounts for a higher conversion rate.

DISCUSSION

Surgeons at MMC began performing laparoscopic cholecystectomy in January, 1991. This followed the classic training of a one-day course in the physiology and techniques of laparoscopy, practical experience in a pig lab and tutoring by experienced surgeons. That year and each year since then, approximately 120 laparoscopic cholecystectomies were done by 5-6 surgeons. Initially, the conversion rate averaged 30% and was the result of operating on patients with advanced disease, conversions for common duct exploration and bizarre anatomy. We have justified our relatively high conversion rate by the fact that no serious common duct injury has occurred in six years. Now the conversion rate has been reduced to approximately 10%- 15%. Currently however, many cholecystectomies are now scheduled as open operations based on the probability of the conversion data developed by this study.

Similar to Traverso's data, Fried's analysis[14] showed factors which predict conversion to open cholecystectomy. He developed a linear regression formula to predict the probability of conversion. However, this was done retrospectively and prospective trials are needed to validate its use.

A simpler approach is to know the probability of conversion for the risk factors and combinations of risk factors in one's own institution before determining which operative approach to use. An individual surgeon's skill or the skill of the collective group of surgeons may be considered. Surgeons with advanced skills would have more tolerance for adverse preoperative findings and would be able to perform laparoscopic cholecystectomy on a more cost-effective level. This methodology assesses that laparoscopic skill and aids in determining what individual or collective threshold should be achieved or tolerated. Moreover, it provides a base from which "Performance Improvement" may be appraised.

When completed, this type of financial and decision-tree analysis can help pick the most efficient way to practice. Acceptance of these findings by physicians, hospital administration and hospital boards is another issue, but the data produced by this method could prove to be powerful in changing behavior and attitude.

This knowledge base also provides information for Continuous Quality Improvement (CQI) or Performance Improvement (PI), as demanded by the JCAHO. Moreover, if hospitals know the costs (not charges) of conversions, laparoscopic cholecystectomy and open cholecystectomy, then the knowledge gained from decision-tree comparisons may be used to develop more profitable contracts with health care providers.

It is important to note that evaluation of the case mix is crucial before reaching conclusions of a hospital's or physician's (in)efficiency. For example, one of the 20 cases evaluated in the DRG 195 was an alcoholic Native-American who developed ascending cholangitis and underwent cholecystectomy and common duct exploration. She remained septic and after one month of intensive care, died of massive upper gastrointestinal hemorrhage from a giant gastric ulcer. Hospital costs alone were $120,000. This case and other similar cases become outliers and must be considered when making proposals for change. Elimination of one or more of these patients from the analysis may show the DRG's average LOS and charge to be close to the average of other regional hospitals.

It is not within the scope of this paper to discuss the reasons of the excess costs of conversion, but an excellent review of these costs and charges in a community hospital is found in an article by Vanek and Bourguet.[15] The main reasons include: more operative time, anesthesia time, cholangiograms, reusable laparoscopic instruments, etc. Experienced analysts also recognize that the charges quoted in this paper are generally excessive and require explanation. The charges are real and can be verified by data collated by commercial vendors. The reasons for these high charges encompass higher laparoscopic equipment costs, prolonged preoperative stays (2-3 days) waiting for an operating room, a higher percentage of patients having advanced disease on an emergency admission and, consequently, complications.

CONCLUSIONS

A step-wise appraisal process using DRG data can be used to screen hospital or physician inefficiencies. Following identification of LOS and charge inefficiencies by DRG screens, individual chart review of that specific DRG can be used to identify the reasons for the inefficiencies (Pareto analysis: about 20% of the items identified account for 80% of the costs). Decision tree analysis and sensitivity analysis can be used to determine the scope of the inefficiencies and measure how much change would be required to make that DRG efficient. This analysis showed that if laparoscopic charges could be reduced at MMC cost-efficient laparoscopic cholecystectomy patients at risk for conversion would be financially acceptable.

These types of evaluations not only provide reasonable financial assessment, but serve to satisfy the requirements of JCAHO for performance improvement.

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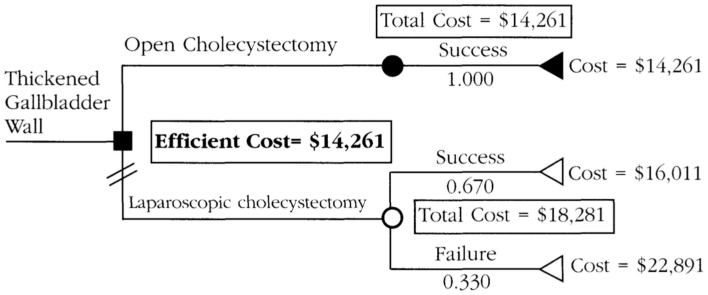

Figure 3. Decision tree for thickened gallbladder wall.

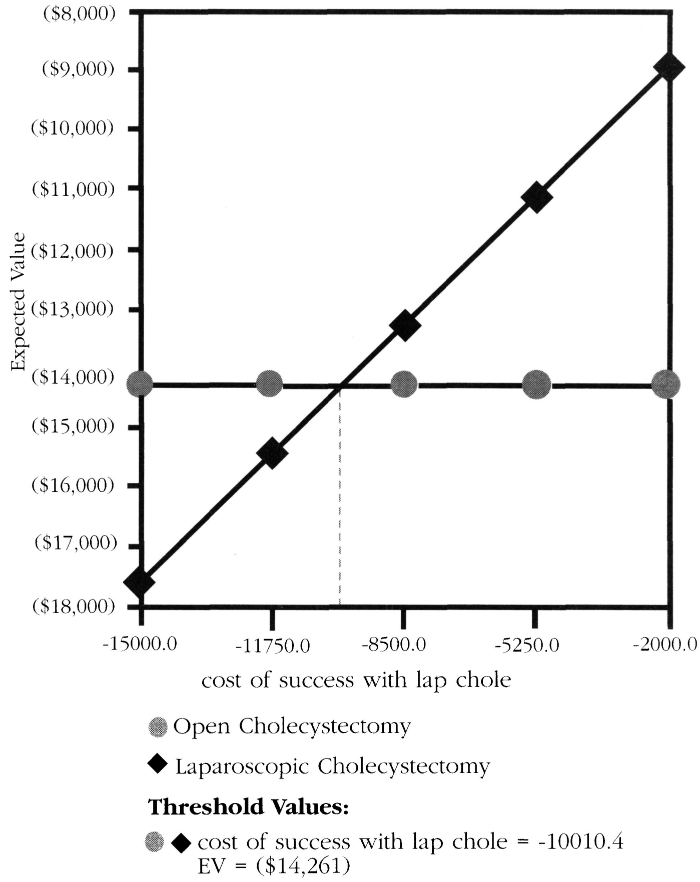

Figure 4. Sensitivity analysis for thickened gallbladder wall.

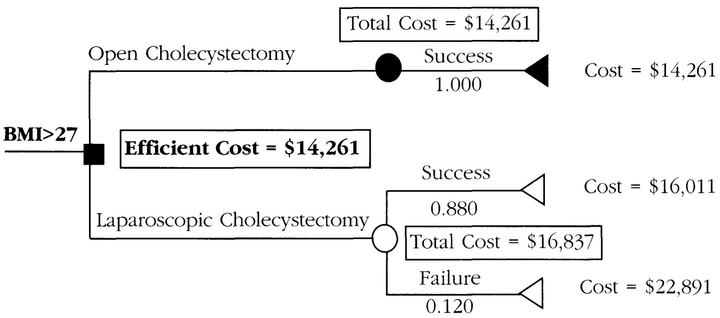

Figure 5. Decision tree for BMI>27.

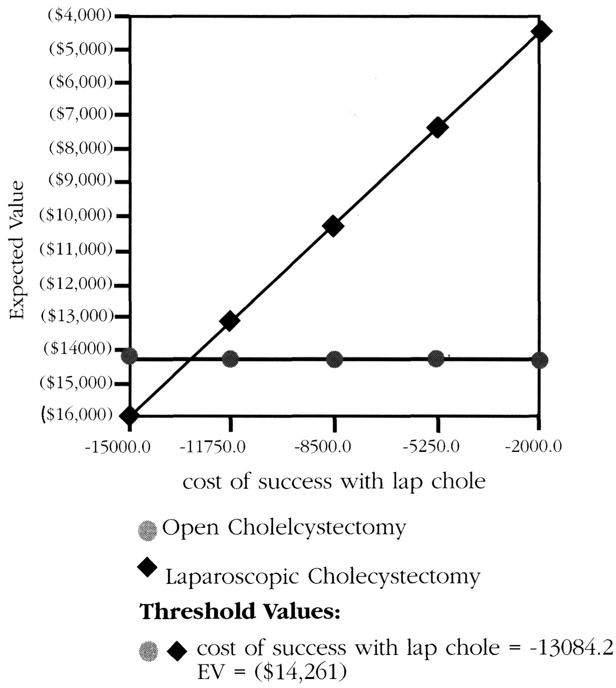

Figure 6. Sensitivity analysis for BMI > 30.

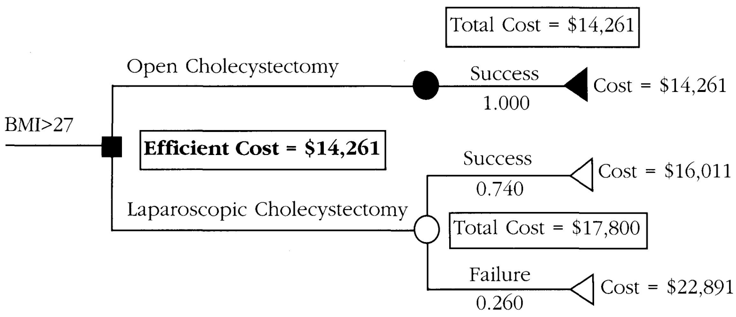

Figure 7. Decision tree for dilated common duct > 1 cm.

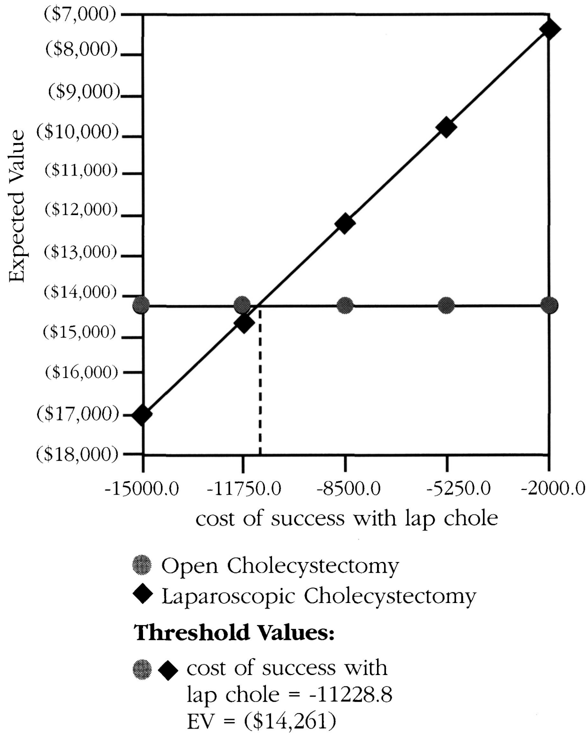

Figure 8. Sensitivity analysis for thickened dilated common duct.

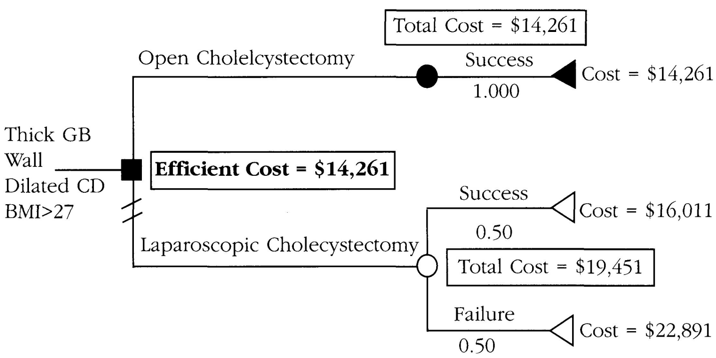

Figure 9. Decision tree for combination of factors @ 50% conversion rate.

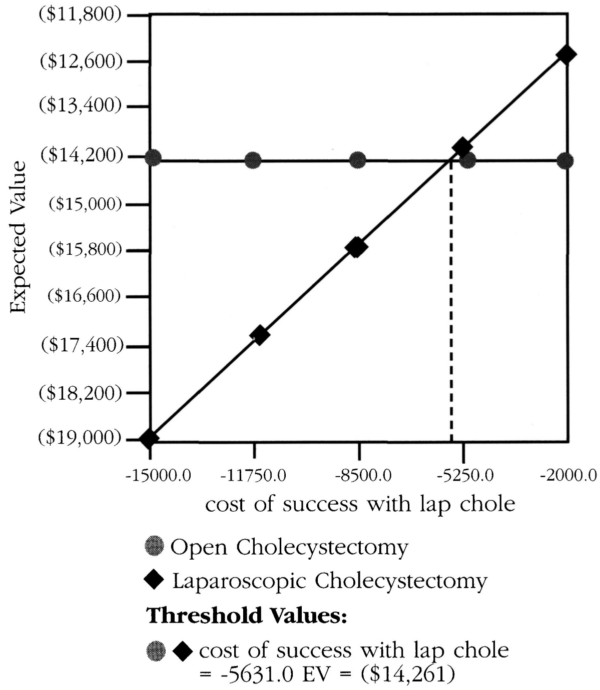

Figure 10. Sensitivity analysis for combinations @ 50% conversions.