COST UTILITY ANALYSIS OF TREATMENT
FOR GALLSTONE DISEASE: INTERIM
RESULTS

Johanna Cook
Senior Research Fellow

Jeff Richardson
Professor and Co-Director

Andrew Street
Research Fellow

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The Co-ordinator
Centre for Health Program Evaluation
PO Box 477
West Heidelberg Vic 3081, Australia

**Telephone** +61 3 9496 4433/4434  
**Facsimile** +61 3 9496 4424  
**E-mail** CHPE@BusEco.monash.edu.au
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The paper considers three options for the treatment of gallstone disease vis, open cholecystectomy, extracorporeal shockwave lithotripsy and laparoscopic cholecystectomy. The analysis includes the direct hospital, treatment and patient costs of these procedures and the indirect, societal cost of foregone production. The reduced quality of life (QoL) associated with each treatment is measured using the techniques of cost utility analysis. Data were obtained from three sets of surveys: a series of open ended interviews of patients’ QoL; a patient questionnaire and a series of population interviews to convert QoL scenarios into utility values using the time trade off and rating scale techniques.

Results imply that, with certain caveats, laparoscopic cholecystectomy is unambiguously superior to the other two techniques with respect to both cost and outcome. Lithotripsy is cheaper than open cholecystectomy but because of its side effects may result in a lower post treatment QoL. Choice of open cholecystectomy may therefore increase healthy year equivalents (HYE-s) but at a treatment cost of $443,000 per HYE. The result is reversed if ursodeoxycholic acid is used as the adjacent bile salt regime. Unlike chenodeoxycholic acid, the use of ursodeoxycholic acid does not result in diarrhoea or nausea. At the time of the trial ursodeoxycholic acid was not available in Australia. The consequence of this is a significant reduction in the loss of HYE-s associated with lithotripsy. With the use of ursodeoxycholic acid, laparoscopic cholecystectomy would remain the cheaper procedure but lithotripsy would result in less loss of HYE-s.

Lithotripsy would unambiguously be the cheapest option if it was available via the spare capacity of multi purpose lithotripters that were independently justified.

Methodological issues discussed in the paper include the measurement of temporary health states, the ex ante and ex post perspectives in cost utility analysis and utility measurement with imperfect patient data.
1 Introduction

It has been estimated that 25 percent of women and 20 percent of men in developed countries will have gallstones at some time in their life and that as many as one million Australians could have them at present (AIH, 1990). Many of these will remain asymptomatic but acute gallstone disease resulted in about 23,000 cholecystectomies in 1988 (AIH, 1990). This conventional treatment (the surgical removal of the gall bladder) causes significant post-operative morbidity. Patients require narcotic analgesics to control the pain. The procedure requires an average length of stay in hospital of seven days post-operatively for uncomplicated cases and a subsequent recovery time of up to six weeks. Patients have limited mobility, they tire easily and sleep badly at night. At the end of the third to fourth week there is normally a rapid recovery with a return to full health in 4-6 weeks.

In the last few years the treatment of gallstone disease has changed dramatically with the availability of two revolutionary new treatments: extracorporeal shock wave lithotripsy (ESWL) and laparoscopic cholecystectomy. ESWL for biliary stones was first used in 1986 by clinicians at the Klinikum Grosshadern in Munich. Gallstones are fragmented by externally generated shockwaves which are transmitted through a column of water to the patient's body. More than one treatment may be necessary to achieve the optimal fragmentation rate. Because the procedure is non-invasive post treatment morbidity is minor and patients can leave the hospital on the same day and the treatment can be scheduled around work and family commitments. To clear the fragments or "sludge" from the gall bladder patients are given oral dissolution therapy until patients are diagnosed as being "stone free". However the treatment can cause significant diarrhoea and some nausea which may be controlled by a reduction in dosage. The symptoms tend to become less severe as the body becomes accustomed to the medication. It is estimated that only about 15% of patients with gall bladder disease are suitable for lithotripsy. Consequently, the more significant development in the treatment of gall bladder disease was the application of laparoscopic surgical techniques.

Laparoscopic cholecystectomy is the most recent technology. The procedure which was first used in France in 1987, is a form of minimal access surgery similar to the techniques used in gynaecological procedures for the last three decades. Post-operative morbidity is significantly reduced. Most patients are out of bed on the day after the operation and are able to return to normal duties two or three days after the operation. As with the alternative procedures there is a small probability of serious complication.

The two recent technologies were introduced into Australia about the same time and a trial was undertaken at St Vincent's Hospital in Melbourne. While this was primarily to evaluate biliary lithotripsy it resulted in the collection of detailed information on a sample of patients undergoing each of the three treatment options, 1 lithotripsy, open and laparoscopic cholecystectomy. This protocol data permitted a detailed economic evaluation of the interventions. Since the quality of life is significantly affected by two of the procedures a cost utility analysis of the alternatives was undertaken.

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1 Two interim reports have been published, see St Vincent's/AIH, 1990, 1992. Options for the treatment of gallstone disease have also been discussed by Hailey (1991).
2. METHODS AND ISSUES

Measuring Outcomes

In principle, at least three approaches could be applied to the measurement of the quality of life (QoL) following each of the interventions. First, a multi-attribute utility (MAU) scale could be used to assess, individually, each patient’s quality of life at different points of time post-operatively. If an additive model is assumed (total healthy year equivalents - HYE-s are the sum of the period by period HYE-s) this approach would yield the total number of HYE-s experienced by the patient population. Two factors made the approach infeasible. First, QoL data collection would have to commence at the onset of the trial. Retrospective analysis would be very difficult. Secondly, and more fundamentally, there is at present no MAU scale that is sensitive to the outcomes that characterise the recovery from the interventions being studied here.

A second approach is to use a battery of appropriately selected (QoL) instruments that are capable of measuring variation in patient experience. In the Sheffield random control trial of biliary lithotripsy patients were given a pain diary based upon the McGill pain questionnaire. Gastro-intestinal and other symptoms were measured on a visual analogue scale and general QoL was monitored using the Nottingham Health Profile. While this approach will yield a very complete descriptive data base it was also infeasible in the present study. As with the first approach, it requires data collection from the beginning of the trial and the present study was constrained to retrospective analysis. More importantly, the data collection may not be capable of yielding a ranking of the procedures. There is no method available for collapsing the descriptive data from the QoL scales into a single index of utility for the calculation of HYE-s. This is required in cost utility analysis to obtain a cost per HYE. In the battery approach outcomes which rate differently on the various indicators are evaluated subjectively unless one option is superior to alternative options in all respects.

The third approach and the one most commonly reported in the economics literature is to develop a number of standard scenarios from retrospective analysis of patient experience and to evaluate these using one of the instruments purporting to measure patient utility. The approach is constrained by the amount of information which can be processed by an individual at any one time. This affects both the volume of information that can be used to construct the scenarios and the number of scenarios that can be evaluated. To mitigate the shortcomings of the approach we constructed "base values" for costs and HYE-s, obtained preliminary results, and then investigated whether these were likely to be altered as the base values were subjected to sensitivity analysis. As the probability and the consequences of the complications of the interventions are subject to significant uncertainty, the base estimates were initially calculated on the assumption that there would be no serious complications apart from death and the implications of other complications are discussed subsequently.

The steps of the analysis are as follows:

1. Construction of an outcome tree for each intervention.
2. The construction of scenarios from patient interviews, questionnaires and expert judgement.
3. Population interviews to evaluate scenarios using a rating scale and the time trade off technique.
5. Comparison with incremental costs.

Data Sources and The St Vincent's Trial

The design of the St Vincent's trial is described in both the first interim report of the St Vincent's Hospital Biliary Lithotripsy Evaluation Subcommittee (1990) and in Hailey (1991). A randomised control trial was not employed because of the difficulty in obtaining agreement from patients and referring specialists, doubts as to whether randomisation criteria would be consistently followed, and the potential difficulty with numbers of patients in each of the arms of the trial.

Patients in the lithotripsy arm of the trial were given the procedure if they met the selected criteria and if they were willing to accept the treatment. When laparoscopic cholecystectomy became available it replaced lithotripsy and open cholecystectomy as the treatment of choice for those patients who met selection criteria. (The criteria for inclusion and exclusion for ESWL treatment and laparoscopic cholecystectomy are given in Appendix 6.) Medical criteria were applied to minimise any possible source of bias in outcome for the three procedures. For example, open cholecystectomy patients with acute cholecystitis were excluded from the study, and stone size and number of stones were not considered to be relevant in the selection of these patients.

While the selection criteria eliminated the most obvious sources of systematic difference between the groups, the structure of the trial allows for the possibility that patients in the three treatment groups may have varied systematically in some respect. Characteristics of the final patient samples are summarised in Table 1. While the table reveals no significant group difference by age or body mass, results were analysed by patient characteristics to determine if there are significant cost differences associated with these attributes. None were found.

For each of the patients in the trial, detailed protocol data were collected on the dates and types of services, procedures, follow up treatments and the drugs received. Some limited information was collected on patient symptoms. Protocols were supplemented by a survey of patients in the trial. This sought detailed information on their experience with pain, diarrhoea, nausea and other post-operative symptoms for the six months following treatment and in the months immediately prior to the survey. The time between the survey and the first treatment varied between patients and, more importantly, between treatment groups. This was the inevitable consequence of the fact that laparoscopic cholecystectomy rapidly replaced the open procedure and lithotripsy as the first choice procedure, and open cholecystectomy patient protocols had to be collected retrospectively for the trial. However, there is no reason to believe that the greater error in the recall of these latter patients should have introduced a systematic bias. Additionally, the questionnaire collected the information needed to estimate patient and indirect costs. Questionnaires were sent to the first 400 lithotripsy patients, all open cholecystectomy patients and to a sample of laparoscopic cholecystectomy patients in the trial. Excluding those who were known to have died or for whom there was no current address, questionnaires were sent to 369 lithotripsy, 79 laparoscopic cholecystectomy and 89 open cholecystectomy patients. The response rate from the 3 groups was 73, 82 and 69 percent respectively giving an overall response rate of 74 percent from the 537 patients approached. Respondents to the survey were tested against the age/sex profile of the patient cohort. For each procedure the age distribution of respondents were similar to that of the total patient population.
### Table 1: PATIENTS IN THE ST VINCENT'S TRIAL

<table>
<thead>
<tr>
<th>Sex</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure</td>
<td>Open Cholecystectomy</td>
<td>Laparoscopic Cholecystectomy</td>
<td>Lithotripsy</td>
<td>Open Cholecystectomy</td>
</tr>
<tr>
<td>Sample size</td>
<td>25</td>
<td>26</td>
<td>128</td>
<td>74</td>
</tr>
<tr>
<td>Public/private&lt;sup&gt;1&lt;/sup&gt;</td>
<td>20/5</td>
<td>15/10</td>
<td>128/0</td>
<td>50/24</td>
</tr>
<tr>
<td>Age&lt;sup&gt;1&lt;/sup&gt;</td>
<td>24</td>
<td>26</td>
<td>127</td>
<td>74</td>
</tr>
<tr>
<td>median</td>
<td>52</td>
<td>41</td>
<td>53</td>
<td>49</td>
</tr>
<tr>
<td>Weight&lt;sup&gt;1&lt;/sup&gt;</td>
<td>22</td>
<td>24</td>
<td>119</td>
<td>59</td>
</tr>
<tr>
<td>median</td>
<td>75</td>
<td>78</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>range</td>
<td>(52 - 105)</td>
<td>(47 - 110)</td>
<td>(52 - 138)</td>
<td>(47 - 110)</td>
</tr>
</tbody>
</table>

**Notes:**

<sup>1</sup> Numbers vary according to the information on each variable for patients. All lithotripsy patients were treated as public patients regardless of actual insurance status.
3. MEASURING HEALTHY YEAR EQUIVALENTS

In cost utility analysis health outcomes are measured in terms of homogenous life years. The adjusted life year is achieved by assigning weights to different health outcomes on a scale from 0 (dead) to 1 (healthy). It is our view that the index used in weighing health outcomes must have a clear and unambiguous meaning (Richardson, 1990). Consequently, we have adopted the term "Healthy Year Equivalents" (HYE-s) to describe what is more often referred to in the literature as quality adjusted life years or QALYs. The term HYE has earlier been used by Mehrez and Gafni (1989) to distinguish the conventional QALY from a unit of outcome derived from the holistic evaluation of multi-stage scenarios. Our use of the term does not imply this process but more accurately describes the final unit of outcome. In the study, both the time trade-off (TTO) and rating scale (RS) techniques were used to measure HYE-s.

Since the treatment of gallstones usually results in a return to normal health the conversion of temporary morbid health states into healthy year equivalents (HYE-s) differs from the measurement of HYE-s for permanent, chronic conditions in two respects. First, rather than measuring HYE-s gained as a result of an intervention we estimated the loss of HYE-s associated with the recovery. The marginal benefit (loss) of HYE-s resulting from the new technologies may be calculated by comparing the HYE loss after the new procedure with the loss following an open cholecystectomy. Secondly, following Torrance (1986) we measured temporary states on scales where the lower reference point was the worst temporary health state identified by the individual and then converted these results into utility values on a 0-1 (death-normal life) scale using the value of the worst health state treated as a chronic condition until death.

An unusual feature of the present study was our attempt to quantify the disutility arising from the anticipation of an operation and the risk of death associated with it. Scenarios were constructed which presented patients with information about the operation to be undergone. The time trade off was used to establish the equivalent disutility measured as weeks in the worst health state. In our case equivalence was used as this technique directly converts a period of ill health into an equivalent period of normal health.

Outcome Tree

The first input into the calculation of HYE-s is the determination of outcomes, their probabilities and transitional probabilities into subsequent health states including cases which are subsequently converted into another treatment modality. Construction of the outcome tree was seriously hindered by the availability of relevant data. First, there is a significant uncertainty about clinical outcomes. The literature is not always consistent or comparable. Our synthesis of this literature, supplemented by expert judgement is presented in Appendix 1. Secondly, and more seriously, patient experience varies significantly within the broad clinical categories (Daly 1991, Brazier 1991) and consequently this review of the clinical literature does not provide sufficient patient oriented data for the construction of the relevant outcome tree.

Two particular problems emerged during the review. Subsequent to each of the treatments a percentage of patients continue to experience acute symptoms which cannot be attributed to the gallstones. This "post-cholecystectomy syndrome" is not well understood but confounds the classification of outcomes as symptoms and clinical results do not correlate. The second problem is the definition of a successful episode of treatment. Studies conducted after bile salt
dissolution show a recurrence rate of approximately 50 percent after 5 years with few further cases after 5 years. There is insufficient clinical evidence to determine the proportion of these which result in subsequent treatment. The best evidence is the finding from a longitudinal study that the cumulative probability of developing biliary pain following discovery of asymptomatic stones by cholecystographic screening is 15% at 10 years and 18% at both 15 and 20 years (Gracie & Ransoloff, 1982). When symptoms do occur they are usually moderate and only 3-7% of cases are severe. (Den Besten, 1988).

The final outcome trees, reproduced in Appendix 3, were constructed as follows. First, broad clinical outcomes and probabilities were determined as shown in Appendix 1. Secondly, patient scenarios were constructed from patient interviews, questionnaires and expert judgement. As discussed above, apart from the clinical outcomes reported in the literature very limited information exists on patient experience following treatment. Consequently the probabilities of different outcomes within the broad QoL outcome groups were determined from the patient survey as shown in Appendix 2. Since patients have imperfect recall of a past procedure the information collected in the survey was limited to the experience in the first six months after the procedure and in the one month immediately prior to receipt of the questionnaire. This latter information was used to interpolate the likelihood of being in a health state beyond the initial six months. While such interpolations may be subject to significant error the proportion of persons in the health state after six months was small. Measurement ceased at 18 months when bile salt treatment for lithotripsy also ceased. If subsequent symptoms are attributable primarily to post-cholecystectomy syndrome, and this is equally distributed between the three treatment groups, then our results are biased somewhat against the cheapest intervention. It is efficient to carry out ineffective interventions cheaply!

Base estimates of the marginal HYE gains were subject to sensitivity analysis with respect to the major values incorporated in the tree. The disutility associated with the anticipation of an operation and the risk of dying represents an interesting methodological issue. This is quantified and discussed separately.

**Common Bile Duct Damage**

The most serious complication arising from open or laparoscopic cholecystectomy occurs when there is damage to the common bile duct (CBD). The consequences are shown in Appendix 3 Figure D1. An estimate of the order of magnitude of the HYE loss due to CBD damage was based upon the following assumptions.

- The probabilities of different consequences are as shown in Appendix 3 Figure D1.
- The average life expectancy of patients is 25 years, the average for the respondents to the survey.
- The disutility of the repair of a stricture is equal to the loss of utility associated with the post-operative health state for open cholecystectomy.
- The loss of utility associated with permanent CBD damage is equal to the loss from the worst health state (0.5) and the loss continues for the rest of life.

**Scenarios**

The health state scenarios which formed the basis for the utility analysis are reproduced in Appendix 4. They were the result of information gathered from 4 sources (1) unstructured
Interviews of patients, (2) the literature, (3) patient questionnaires, (4) medical advice. The latter source was used to construct the inhospital post-operative scenario for open cholecystectomy. As used here it is the surgeon's description and not the patient experience that represents the gold standard.

The results of earlier qualitative research are presented in Daly (1991). This study indicated significant differences in the patient experience following lithotripsy. Consequently, it was decided to conduct a series of individual interviews with lithotripsy patients as well as laparoscopic cholecystectomy patients. The principles behind such an approach are described by Glaser & Strauss (1987). In the event the results indicated an even greater diversity of experience than anticipated, a conclusion confirmed by the preliminary results from the Sheffield experience which became available (Brazier 1991). It was therefore decided that the survey results should be used to define broad categories of patient experience with the initial interview results being used to develop the scenarios within these categories. The terminology of the scenarios was based upon the typical descriptions of symptoms given by patients. During the piloting of the interview the narrative style of the scenarios was replaced by an enumeration of quality of life items as a response to the cognitive overload of those interviewed. To reduce the interview burden and the likelihood of cognitive overload, only health states within the `normal' range were included in the interview. The treatment of complications is discussed later. In addition, the utilities of four health states were estimated from the values directly obtained from respondents. The loss of utility associated with moderate to mild pain following laparoscopic cholecystectomy was set equal to HS7 (moderate pain) while the loss of utility associated with post-operative discomfort only following open cholecystectomy was set equal to HS2. Assuming an additive model, the loss of utility associated with the most severe post operative health states were calculated in the following manner. For open cholecystectomy loss of utility in the severe post operative state was set equal to the loss of utility of the `normal' post operative health state (HS1) plus the loss of utility associated with severe pain alone (HS4). For laparoscopic cholecystectomy, the loss of utility in the severe post operative state was calculated as the loss of the moderate to mild pain following laparoscopic cholecystectomy (HS7) plus the loss of utility associated with severe pain alone (HS4).

**Interviews**

On the basis of the anticipated standard error, a target sample of 96 was sought to obtain utility values. SES profiles based on the indicators of socio-economic disadvantage by Ross, et al (1988) were drawn up from postcodes of St Vincent's Hospital patients. To simplify the sampling procedure these profiles were divided into an upper and lower SES groups and the median SES value in each group was used to identify the area from which to recruit members of the general public. The educational status of respondents was used as an indicator of SES. Women were over sampled to reflect the gender difference in the incidence of gallstone disease.

Interviewing was carried out, by appointment, in the respondent's home. Three experienced interviewers were employed and trained to use the measurement techniques and visual aids. Subsequent interviews were observed to ensure quality control. Results from different interviewers will be examined statistically to control for any systematic differences, if any, between interviewers.
Results

With both the RS and TTO technique 80 percent of respondents nominated health state 3 as the worst scenario, the remainder nominating either health state 1 or 6 (See Appendix 4). The value of these as chronic health states for 12 months were used to convert other health states into utilities on a 0-1 scale. As the utility values for the chronic health state could be subject to serious bias arising from the assumed life expectancy they were compared with values obtained from the same health state and an assumed life expectancy of twelve years. No significant difference was found. With the TTO the correlation between the two was 0.83 and the mean values were 0.45 (months) and 0.41 (years). The mean values would have been identical if a 2 percent discount rate was applied over the 12 years. The correlation between the rating scale values was 0.64 and the mean values were 0.35 (months) and 0.29 (years). This difference was not significant at the 5 percent level. Results from the shorter time period were used for utility calculations as they are the theoretically correct values for the calculation of health state preferences if Torrance's method is used.
Table 2: UTILITY VALUES FROM THE SEVEN HEALTH STATES: MEANS AND CONFIDENCE INTERVALS

<table>
<thead>
<tr>
<th>HEALTH STATES*</th>
<th>TIME TRADE OFF</th>
<th>RATING SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>1 Open cholecystectomy (normal)</td>
<td>0.81</td>
<td>0.75 - 0.86</td>
</tr>
<tr>
<td>2 Laparoscopic cholecystectomy (normal)</td>
<td>0.91</td>
<td>0.87 - 0.92</td>
</tr>
<tr>
<td>3 Severe pain/severe diarrhoea/nausea</td>
<td>0.49</td>
<td>0.38</td>
</tr>
<tr>
<td>4 Severe pain (periodically)</td>
<td>0.87</td>
<td>0.62</td>
</tr>
<tr>
<td>5 Severe diarrhoea</td>
<td>0.81</td>
<td>0.58</td>
</tr>
<tr>
<td>6 Moderate pain/severe diarrhoea</td>
<td>0.68</td>
<td>0.48</td>
</tr>
<tr>
<td>7 Moderate pain</td>
<td>0.88</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Notes:

* See Appendix 4 for Health State descriptions

Utility values for the seven health states are given in Table 2. In all cases the mean values differ significantly from full health (1.00). Standard errors were comparatively small indicating a degree of concurrence between respondents about the value of the health states. The most striking result in Table 2 is the discrepancy between the values obtained from the rating scale and the time trade off technique. The former are consistently and significantly lower and, applying the test of "reflective equilibrium" used by Nord et al (1992) they are implausibly low. (The rating scale results imply that 5 people "feeling tired, uncomfortable, unable to lift heavy things but able to do normal activities - health state 2 - would be equivalent to 1 person being dead".) Subsequent results are based upon TTO values which are arguably the theoretically preferred basis (Richardson 1990). The second striking result is the importance, on both scales, of the symptoms that are unique to adjuvant bile salt therapy following lithotripsy. The loss of utility from moderate pain plus severe diarrhoea is almost double the loss from pain
alone and the loss from severe pain/severe nausea is almost three times as great on the TTO scale as the loss from severe pain.

Preliminary results from an analysis of variance indicated no significant difference in utility values by sex but significant differences by both age and education. The former differences are quantitatively insignificant but the latter indicate a statistically significant difference between the best and worst.

Table 3: LOSS OF HEALTH MONTH EQUIVALENTS PER PATIENT(1)

<table>
<thead>
<tr>
<th>PROCEDURE</th>
<th>Open Cholecystectomy</th>
<th>Laparoscopic Cholecystectomy</th>
<th>Lithotripsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: QoL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. First 6 months (low)</td>
<td>0.60</td>
<td>0.33</td>
<td>0.84</td>
</tr>
<tr>
<td>2. 18 months</td>
<td>1.14</td>
<td>0.79</td>
<td>1.46</td>
</tr>
<tr>
<td>3. 18 months (Hi)(2)</td>
<td>1.42</td>
<td>0.99</td>
<td>1.83</td>
</tr>
<tr>
<td>B: Death</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Lower estimate</td>
<td>0.30</td>
<td>0.36</td>
<td>0.03</td>
</tr>
<tr>
<td>2. Upper estimate</td>
<td>0.60</td>
<td>0.66</td>
<td>0.66</td>
</tr>
<tr>
<td>C: CBD Damage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Lower estimate</td>
<td>0.02</td>
<td>0.02</td>
<td>-</td>
</tr>
<tr>
<td>2. Upper estimate</td>
<td>0.06</td>
<td>0.47</td>
<td>-</td>
</tr>
<tr>
<td>D: Operation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Median</td>
<td>0.50</td>
<td>0.25</td>
<td>0</td>
</tr>
<tr>
<td>4. Mean</td>
<td>1.12</td>
<td>0.90</td>
<td>0</td>
</tr>
<tr>
<td>E: Full Procedure (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. 6 month: A1 + B1 + C1</td>
<td>0.92</td>
<td>0.71</td>
<td>0.87</td>
</tr>
<tr>
<td>2. Base: A2 + B1 + C1</td>
<td>1.46</td>
<td>1.17</td>
<td>1.49</td>
</tr>
<tr>
<td>3. Upper: A3 + B2 +C2</td>
<td>2.08</td>
<td>2.12</td>
<td>2.51</td>
</tr>
<tr>
<td>4. ex ante: A2 + C1 + D1</td>
<td>1.66</td>
<td>1.06</td>
<td>1.46</td>
</tr>
</tbody>
</table>

Notes:
(1) The loss of Health Month Equivalents (HME-s) is calculated as the sum of the probabilities of being in each state times the loss of utility (1 – utility index) times time in the health state. Probabilities are given in Appendix 2.
(2) Loss of HME-s increased by 25%.
(3) Adjusted for conversions: 10 percent of laparoscopic become open cholecystectomies; 20 percent of lithotripsy patients receive laparoscopic cholecystectomy after 13 weeks (median time experienced) during which the average utility experienced was assumed equal to the average for patients in the first 2 months following lithotripsy.

Results from Table 2 were combined with the outcome data in Appendices 1 and 2 to calculate the loss of healthy month equivalents (HME-s) after each of the 3 procedures. (Note: one HME is 1/12 of one HYE.) The results, reported in Table 3, decompose the HME-s into the principal cause of the loss. The loss of HME-s is calculated as the sum of the probabilities of being in each health state times the loss of utility (1 - utility index) times time in health state. The average loss of HME-s from death and common bile duct damage are an estimate of the loss of HYE-s from both death and CBD respectively multiplied by the probabilities of the event.

educated groups. No adjustment has been made for this in the present report. The reason for the association will be investigated when the final results are analysed.
Results are presented in Table 3. Row A1 indicates the estimated QoL loss from the first six months post treatment only. Data were most reliable over this period and it would be expected that the major loss attributable to the procedures would have occurred in this time. As expected, the effect of open cholecystectomy on QoL is significantly larger than from an uncomplicated laparoscopic cholecystectomy. The much worse result from lithotripsy reflects the strong disutility associated with its side effects.

As reported in Appendix 2, a significant percentage of patients reported symptoms "attributable to the procedure" after 6 months. About 30 percent reported continued mild pain after both laparoscopic cholecystectomy and lithotripsy. This is consistent with overseas evidence. Even though the result may be primarily attributable to post-cholecystectomy syndrome it should be included in an evaluation. Consequently the 6 month time frame underestimates the QoL effects. The 18 month results increase the apparently worse QoL experience after lithotripsy. The increase is attributable to a small percentage of patients reporting continual strong pain and diarrhoea after 6 months.

The poorer outcome from lithotripsy is partly offset when the results include the likelihood of death. The lower estimate for mortality after lithotripsy, based upon world-wide experience, is significantly lower than mortality rates from the other two procedures. The upper estimate from lithotripsy is based upon a single (subsequent) death of a patient in the St Vincent's series who developed pancreatitis one month after ESWL but received treatment for this elsewhere. It is unlikely to represent the true mortality rate in a centre such as St Vincent's where patients have access to ERCP sphincterotomy.

The most unreliable estimates in Table 3 relate to the outcome of common bile duct damage. However the very small probabilities of this outcome reduce its importance except for the upper estimate of CBD associated with laparoscopic cholecystectomy. If this estimate is correct or conservative then this factor could alter the very clear superiority of the procedure over open cholecystectomy. It would still be associated with a lower average loss of HME-s than from lithotripsy.

The final *ex ante* result reported in Table 3 Row E4 does not include the average effect of realised deaths. From the *ex ante* perspective the relevant object of measurement is the disutility of anticipated death and the inclusion of this plus the *ex post* measure of mortality would represent double counting. Since the best estimate of mortality associated with lithotripsy is virtually zero we did not include a value for the disutility associated with the procedure *per se*. This improves the relative position of lithotripsy. It remains inferior to laparoscopic cholecystectomy but superior to open cholecystectomy.
Table 4: Value of the Operation
Loss of weeks of life equivalent to undergoing an operation
(Percent Distribution)

<table>
<thead>
<tr>
<th>HEALTHY WEEK EQUIVALENT(^{(1)})</th>
<th>OPERATION ALONE(^{(2)})</th>
<th>OPERATION PLUS WEEK IN HOSPITAL(^{(2)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.5</td>
<td>22.4</td>
<td>14.3</td>
</tr>
<tr>
<td>0.5 - 1.0</td>
<td>21.0</td>
<td>19.5</td>
</tr>
<tr>
<td>1.0 - 1.5</td>
<td>19.8</td>
<td>11.7</td>
</tr>
<tr>
<td>1.5 - 2.0</td>
<td>10.5</td>
<td>6.4</td>
</tr>
<tr>
<td>2.0 - 3.0</td>
<td>6.6</td>
<td>20.8</td>
</tr>
<tr>
<td>3.0 - 10</td>
<td>13.1</td>
<td>19.5</td>
</tr>
<tr>
<td>10 - 15</td>
<td>5.3</td>
<td>6.5</td>
</tr>
<tr>
<td>&gt; 15</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Mean</td>
<td>3.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Median</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Range</td>
<td>0 - 119</td>
<td>0 - 119</td>
</tr>
</tbody>
</table>

Notes:

\(^{(1)}\) The option of an operation was traded off against weeks in the worst health state. The table reports these weeks adjusted by the loss of utility in the worst health state.

\(^{(2)}\) Scenarios are reproduced in Appendix 4.

The typical *ex ante* result subsumes an important and relevant consideration. To calculate the disutility of an anticipated operation the option of an operation was traded off against weeks in the worst health state. The resulting equivalent time was then adjusted by the loss of the utility of the worst health state. As shown in Table 4 the disutility of an anticipated operation measured in this way varies significantly. While the typical or median response was to equate the operation risk, plus one weeks hospitalisation with 0.5 HME-s (2 "healthy week equivalents"), 27.3 percent of respondents had a values at least 50 percent above this and 7.8 percent had values above 2.5 HME-s. This strength of feeling towards an operation would result in these individuals exhibiting a strong preference for lithotripsy, all else being equal. Similarly, a small percentage of respondents revealed a strong disutility associated with an operation alone - the case of laparoscopic cholecystectomy. Thirty percent of respondents gave values sufficiently high that the overall disutility of a laparoscopic cholecystectomy would exceed the disutility of lithotripsy, all else equal.
4. COSTS

The economic cost of an intervention includes the direct cost to the health system, the patient, and the indirect cost arising from the loss of (paid or unpaid) productive activities. Williams (1992) and others have argued that indirect costs may sometimes be ignored as those who leave the workforce will be replaced from the pool of unemployed. Irrespective of the validity of this argument in other contexts it does not apply here. The loss of productive activity associated with the treatment of gallstone disease is normally for a period of time which is too small for the individual to be replaced costlessly. Consequently we have included the following costs in the analysis.

A Hospital costs: ........................................................ Medical, theatre and nursing; 
........................................................ Diagnostic tests and medication; 
Overheads, capital and rental.

B Patient costs: .......................................................... Transport and travel time.

C Indirect costs: .......................................................... Lost production (paid and unpaid).

With each of the three procedures most of the treatment costs occur within the hospital and there are two approaches to estimating these. The first and simpler approach is to sum the global costs associated with each option and divide by the number of cases treated to obtain an average cost per treatment. The second approach is to attribute costs to each patient in accordance with their resource use and subsequently to compute a simple or weighted average cost for treatment. A pre-requisite to the second approach is the existence of a patient based information system. These will become increasingly available with the implementation of Management Information Systems (MIS) in hospitals. At the time of the study the St Vincent's MIS was not sufficiently developed to be of assistance but the existence of the patient protocols described earlier made this approach feasible.

Despite the greater effort involved, the second, patient based approach was adopted because of its significant methodological advantages. The St Vincent's trial described earlier did not achieve perfect matching of patients. The second approach permits costs to be compared by patient characteristics and adjustment to be made when these cost differences are significant. Similarly the approach allows for the testing of cost differences by characteristics such as age, sex, body weight, or stone size.

Discretionary Issues

Most of the decisions in the cost analysis were associated with the determination of unit prices for each of the inputs and the quantity of each resource used. However, four discretionary issues arose. The first was the valuation of the physician’s time. Two options were available, either to use the fee that could be obtained in the private sector for the procedure, or to impute the cost from the physicians’ sessional payments at the hospital and the time spent with or attributable to each patient. The estimates differ significantly and both are imperfect measures of resource (opportunity) cost. Private fees represent the opportunity cost of time only if all of the fees charged by a fully employed doctor incorporate the same net value per unit of time. The relationship between VMO sessional payments and opportunity cost is unclear with
assertions that they are artificially low in Victoria as a quid pro-quo for access to public facilities. The approach adopted here was to incorporate the second and lower figure in the ‘base estimates’ of costs and subsequently to test the sensitivity of total costs using the higher, private fees based estimate.

The second issue was the treatment of fixed costs. It is arguable that, on the margin, wards would not open or close because of treatment choice and consequently no rental cost should be attributed to individual patients. However, as there is an opportunity cost in the use of a hospital bed (normally the non-use by another patient) we have adopted the conventional practice of imputing rental value per bed-day based upon the rental value of comparable space. The more important issue is the treatment of the fixed cost of the lithotriptor. As it was under-utilised in the St Vincent’s experiment the cost per patient would be very high and result in a distorted estimate of the cost per treatment with a fully utilised machine. Consequently, an estimate was made of the average fixed cost based upon the assumption that the machine was used to its normal full capacity.

The third discretionary issue was the imputation of the indirect cost of lost production. As the survey achieved a response rate of less than 100 percent it was not possible to include these costs with the unit records and they were combined globally. More importantly, since the indirect cost of the lost time of those in the paid workforce is greater than for other patients, the estimated value of indirect costs of each procedure is sensitive to the percentage of the patients in the workforce. In a randomised control trial this percentage should be the same for each group of patients. In fact, the percentage of patients receiving open cholecystectomy who were in the paid workforce was significantly lower than for the other two groups. Consequently the indirect costs for this group were adjusted to reflect the same workforce participation as in the other two groups.

The final discretionary issue was analogous to the third. Because of the experimental nature of the ESWL at St Vincent's the patient catchment area was very large and the travel costs of some lithotripsy patients correspondingly high. If ESWL became the preferred treatment option and the technology diffused throughout the country these costs would be reduced. Consequently, the same travel times were imposed on lithotripsy patients with cost differences reflecting the number of visits.

There is a detailed description of the methods and data sources used for the costing of the three procedures in Street (1993). These are summarised below.

**Theatre and Medical**

Although all those receiving ESWL were treated as public patients, those having surgery were a mix of public and private patients. In estimating the surgical cost it was first assumed that all were public patients. Then charges for the treatments made in the private sector were investigated.

The average surgical cost for each procedure was estimated using the hospital's information on theatre time and using an estimate of the time spent with patients in addition to this. Similarly, the cost of the physician performing ESWL was calculated according to the time spent with the patient. The most common hourly sessional rate among the various physicians at St Vincent's Hospital who performed the procedures was used to cost this time. The cost was calculated as, on average, $191, $187, and $89 for open cholecystectomy, laparoscopic cholecystectomy, and lithotripsy patients respectively.
For the second estimate of medical costs the total `cost' for open and laparoscopic cholecystectomy was determined by the average fee charged by physicians in the fourth quarter of 1991. The average charge amounted to $579. As there was no rebate for biliary lithotripsy the private rate was set equal to the rebate for ESWL to the urinary tract, which also specifies three days of post-treatment care. In the fourth quarter of 1991, the average charge for this item number was $614.

There are a variety of other staff associated with the conduct of an operation, some of whom are present during the operation; others are required before or after the operation. The salary costs for the former group were applied to the length of the operation and the costs of the latter estimated from the average pre and post-operative periods of activity. The cost of the theatre staff was estimated as $291 for open cholecystectomy and $318 for laparoscopic cholecystectomy. A nurse and an ultrasonographer were present when patients received ESWL treatment, the cost of these staff being estimated as $96.

The equipment and anaesthetics used in the operation were estimated as amounting to $279 for open cholecystectomy patients and $345 for laparoscopic cholecystectomy. These figures include the cost of medication received subsequent to the operation.

**Nursing**

Nursing costs for patients treated by surgery vary significantly with the intensity of the care. Consequently estimates of the cost of nursing were based on the patient dependency system in use at St Vincent's Hospital. Three wards were examined using the shift specific dependency system at the hospital. For each shift spent at a particular dependency level the patient's time requirement of each category of nursing staff (student, registered and charge nurse) was multiplied by the hourly salary for that shift and for the nursing category. Because the actual dependencies of patients in the study had not been recorded the resulting shift specific dependency level costs were applied to more recent open or laparoscopic cholecystectomy patients to derive an average nursing cost per bed day. These average costs were then applied to patient in the study, according to their lengths of stay. The average cost of nursing staff was estimated as being $984 for open cholecystectomy patients and $588 for laparoscopic cholecystectomy patients.

**Diagnostic Tests**

Patient protocol data gave the number and type of diagnostic tests and investigations carried out for each patient. In the absence of independent cost data for each of these, unit costs were set equal to the CMBS benefit of 75 percent of the schedule fee. As these costs are a very small percent of the total this simplification does not introduce significant bias. The cost of these tests was estimated as $180 for open cholecystectomy and $182 for laparoscopic cholecystectomy patients.

When lithotripsy patients attended for their initial consultation and for follow up, a variety of tests and investigations were performed, the most common being ultrasound. The average cost of the initial consultation and follow up have been estimated according to the tests performed, and for the latter, the number of follow up attendances. On average, lithotripsy patients attended for more than five follow up sessions. The average cost of the initial
consultation was estimated as $70, and the average cost per patient of follow up amounted to $458.

**Bile Salts**

In the case of lithotripsy the major drug expenditure was for bile salts, which are taken to dissolve the stone fragments which remain after ESWL treatment. Patients were prescribed chenodeoxycholic acid (Chendol) according to their body weight. When declared stone free, patients were prescribed bile salts for a further three months. If stones or fragments remained patients either underwent surgery, or continued to take bile salts. Patients who subsequently underwent surgery had taken bile salts for an average of three months. For patients who neither had surgery nor were declared stone free it was assumed that medication continued for eighteen months. The average cost of bile salts was estimated as $1065 per patient.

**Overheads, Capital and Rental**

The cost of consumables and laundry services was calculated by dividing the total bill for the year from June 1991 for the relevant patient wards by the total number of bed days in the wards during this period. The cost of all other hospital overheads, including catering, cleaning, electricity, medical and nursing administration, and general services, was calculated by dividing the total amount paid for these items by the hospital by the total bed days for the year from June 1991. Except for catering, it was assumed that 20 percent of these overhead costs could be attributed to out-patient activity. Hospital overhead costs were estimated at $1286 for open cholecystectomy, and $814 for laparoscopic cholecystectomy patients.

As discussed earlier the cost of a bed day included a rental component. This was calculated from ward size (in square metres), the number of beds in the ward, and the rental cost of a similar area of office space near the hospital. A similar rental cost was calculated for each episode of lithotripsy but with the additional assumption that the lithotriptor was used at normal capacity. The current cost of a lithotriptor and the cost of installing an operating theatre at St Vincent's were depreciated over five and sixty years respectively using a straight line depreciation technique. Interest on foregone capital was set at the ten year government bond rate of 8.9 percent. Capital and rental costs were estimated at $90 for open and laparoscopic cholecystectomy patients, and $1326 per treatment on the lithotriptor.

**Travel and Indirect Costs**

Estimates of travel and indirect costs were derived from questionnaires that were sent to all open cholecystectomy patients, selected laparoscopic cholecystectomy patients and the first 400 lithotripsy patients. An overall response rate of 74 percent was achieved. Although response rates from the different categories of patients were similar the quality of the information may have differed. The time lapse between receiving treatment and receiving the questionnaire differed. All open cholecystectomy patients were treated at least a year before receiving the questionnaire as were approximately half of the lithotripsy patients. For each procedure the age distribution of respondents were similar to that of patients.

Questionnaires included information on the number of trips to hospital, the distance, and mode of transportation. On average, lithotripsy patients travelled significantly further than other patients and, for the reasons discussed earlier, results were adjusted to incorporate the assumption that all patients lived the same distance from the hospital. The direct cost of travel
therefore reflects the mode of transport and the number of trips made. The time cost of travel was determined using an estimate of 40 percent of average weekly earnings (Sharp 1987).

Respondents were categorised as being in the paid workforce, occupied by home duties or retired/unemployed. Indirect costs were calculated using the average weekly earnings for the first group of respondents and ABS estimates of the value of home duties for the second category (Castles 1990). No productive value was attributed to the remaining group as the effects of treatment on non-productive time is subsumed in the outcome measure, vis the number of healthy year equivalents. The patient and indirect costs incurred during the course of treatment were estimated as being, on average, $2887 for those who had open cholecystectomy, $1298 for those who had laparoscopic cholecystectomy, and $622 for lithotripsy patients.

Conversion to Other Treatments

It was estimated that 10 percent of patients undergoing laparoscopic cholecystectomy would have to convert to open cholecystectomy during the operation for technical reasons. Thereafter they would incur the costs of a patient who had undergone open surgery. The cost of a conversion was estimated as being $6760. The average total cost of laparoscopic cholecystectomy has been adjusted to account for the possibility of conversion.
### Table 5: TREATMENT COST PER PATIENT

**A. AVERAGE HOSPITAL COST**

<table>
<thead>
<tr>
<th></th>
<th>OPEN CHOLECYSTECTOMY</th>
<th>LAPAROSCOPIC CHOLECYSTECTOMY</th>
<th>LITHOTRIPSY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>SURGEON</td>
<td>191</td>
<td>187</td>
<td>70</td>
</tr>
<tr>
<td>TESTS</td>
<td>180</td>
<td>182</td>
<td></td>
</tr>
<tr>
<td>THEATRE</td>
<td>291</td>
<td>318</td>
<td>2332</td>
</tr>
<tr>
<td>Staff</td>
<td>279</td>
<td>345</td>
<td>458</td>
</tr>
<tr>
<td>Equipment</td>
<td>90</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Capital</td>
<td>984</td>
<td>588</td>
<td>1065</td>
</tr>
<tr>
<td>NURSING</td>
<td>1286</td>
<td>814</td>
<td></td>
</tr>
<tr>
<td>WARD &amp; HOSPITAL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OVERHEADS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3302</td>
<td>2524</td>
<td>3925</td>
</tr>
</tbody>
</table>

**B. AVERAGE PATIENT AND INDIRECT COSTS**

<table>
<thead>
<tr>
<th></th>
<th>OPEN CHOLECYSTECTOMY</th>
<th>LAPAROSCOPIC CHOLECYSTECTOMY</th>
<th>LITHOTRIPSY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>PAID WORK</td>
<td>2251</td>
<td>1030</td>
<td>364</td>
</tr>
<tr>
<td>HOME DUTIES</td>
<td>531</td>
<td>179</td>
<td>68</td>
</tr>
<tr>
<td>TRANSPORT</td>
<td>79</td>
<td>67</td>
<td>144</td>
</tr>
<tr>
<td>TRAVEL TIME</td>
<td>25</td>
<td>22</td>
<td>46</td>
</tr>
<tr>
<td>TOTAL INDIRECT AND PATIENT COSTS</td>
<td>2887</td>
<td>1298</td>
<td>622</td>
</tr>
</tbody>
</table>

**A. + B. TOTAL HOSPITAL & PATIENT COSTS**

|                      | 6189                  | 3822                        | 4547        |

**C. TOTAL ADJUSTED HOSPITAL & PATIENT COSTS**

|                      | 6189                  | 4116$^3$                    | 5033$^4$    |

**Notes:**

1. Does not include the cost of conversion to open surgery when this occurs.
2. Does not include the cost of surgery when this occurs.
3. The cost of conversion from laparoscopic to open cholecystectomy was calculated as $6760.
4. The cost of laparoscopic cholecystectomy was used in calculating the cost of surgery subsequent to lithotripsy, bringing the total treatment cost for such patients to $6976.
In the same way, 20 percent of patients who had lithotripsy subsequently were admitted for surgery. It has been assumed that patients having surgery had laparoscopic cholecystectomy with a 10% probability of conversion to the open procedure. The average cost of laparoscopic cholecystectomy has been used in calculating the cost of conversion from lithotripsy.

The total average cost of treatment was estimated as being $6189 for open cholecystectomy, $4116 for laparoscopic cholecystectomy, and $5033 for lithotripsy. Details are presented in Table 5.
5. MARGINAL COST-BENEFIT RATIO

As acute gallstone disease is always treated, there is no purpose in estimating total cost-benefit ratios. Such a calculation would be based upon a comparison with a purely hypothetical scenario in which the symptoms of the disease continued until death or spontaneous remission. The two policy issues to date have been a comparison of the costs and benefits of open cholecystectomy and lithotripsy and, more recently, a comparison of lithotripsy with laparoscopic cholecystectomy. The marginal costs and benefits relevant to these choices are presented in Table 6. By contrast with Table 3, the table reports benefits *gained* by the change of procedure, and these are measured in healthy *year* - not *month*-equivalents. As the study was limited to patients without acute cholecystitis and patients who met the other eligibility criteria of the St Vincent's trial, the results in Table 6 are limited to this sub-group of the patient population.

Base estimates of hospital costs and total costs are presented in rows (1) and (2) of Table 6. The consequence of varying utility values are shown in rows (3) to (5) and the results of some speculative assumptions about the clinical outcome from lithotripsy in the rows (6) to (8). The first column of each comparison reports the estimated *difference* in the cost of treating one hundred patients by the two procedures being compared. The second column gives the positive or negative *gain* of healthy month equivalents - converted to healthy year equivalents (HYE-s) - associated with a change. Column (3) gives the marginal cost-benefit ratio ie. the ratio of the first two columns. Interpretation of the ratio is not straight forward. A positive ratio may indicate the usual relationship envisaged, *vis a vis*, an increasing cost associated with an increase in benefit from the new technology. A positive sign also occurs with decreasing marginal costs and benefits. That is, a positive sign only indicates that there is a trade off. Conversely a negative ratio indicates no trade off: either a reduced cost is associated with increased benefits or *vice versa*.

The comparison between open cholecystectomy and lithotripsy is dominated by the cost differences. As shown in Table 6 there is little difference in the base estimate outcomes, measured in HYE-s over the eighteen month period considered here. The initial post surgery discomfort following an open cholecystectomy is more than offset by the high negative valuation placed upon the side effects of bile salt therapy. Lithotripsy becomes the preferred option in terms of HYE-s is when the large disutility of an anticipated operation is included in the calculation (row five). Furthermore, except for the upper estimate we could not reject the hypothesis that the outcomes of the two procedures were the same with reported differences reflecting errors in the estimated probabilities.\(^2\) An interesting result is the importance of indirect patient costs - often omitted in cost utility analysis. In their absence, the direct hospital cost of an open cholecystectomy is less than the average cost of lithotripsy. However, the absence of cholecystectomy patients from the paid and unpaid workforce results in a greater societal cost from this procedure.

With some caveats the comparison of laparoscopic cholecystectomy and lithotripsy suggests the superiority of the surgical procedure. For the first five estimates in Table 6 both the cost of the surgery and the outcome are superior. As noted earlier, the upper estimate of lost HYE-s is probably distorted in the case of lithotripsy where the assumed mortality is based upon the

\(^2\) The data used do not permit the calculation of a standard error for the estimated probabilities of different health outcomes and so the hypothesis cannot be treated formally.
single death of a patient in the St Vincent's series. If this was replaced by the lower estimate of mortality then the loss of QoL from lithotripsy in row (4) would be less than from laparoscopic cholecystectomy as a result of the large impact of common bile duct damage in this estimate. More specifically, the loss of HME-s for lithotripsy would be reduced from the upper estimate of 2.51 to 1.88 as compared with 2.12 for laparoscopic cholecystectomy. This is equivalent to a loss of 5.25 HYE-s per 100 patients, ie (1.88 - 2.51) ÷ 12 x 100 which is two HYE-s less than the loss from laparoscopic cholecystectomy. However the HYE gain from choosing lithotripsy would be at a cost of $32,400 per HYE. As noted, the likelihood of CBD damage is also subject to significant uncertainty.

In row (6) there is a tentative exploration of the order of magnitude of the impact of stone recurrence after lithotripsy. It is based upon the following assumptions.

- 50 percent recurrence, 18 percent of whom will require treatment: i.e. 0.6% per annum for 15 years.
- 12 months prior to treatment patients will experience periodic severe pain (health state 4).
- Subsequent treatment is by laparoscopic cholecystectomy which results in average costs and outcomes, including a 20 percent conversion to open cholecystectomy.
- A discount rate of 5 percent.

These values raise the average cost for patients commencing with lithotripsy from $5033 to $5302 or by 5 percent from the base cost. The number of HME-s foregone increases by 12 percent from 1.49 to 1.67. This increases the absolute disadvantage of lithotripsy when it is compared with laparoscopic cholecystectomy. Lithotripsy remains a cheaper option than open cholecystectomy but the loss of

\[\text{Table 6: MARGINAL COSTS AND BENEFITS PER 100 PATIENTS}\]

<table>
<thead>
<tr>
<th></th>
<th>Lith minus Open Chol (1)</th>
<th>Lap Chol minus Lith (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost(3)  HYE GAIN(4) Ratio $000 Choice</td>
<td>Cost(3)  HYE GAIN(4) Ratio $000 Choice</td>
</tr>
<tr>
<td>1. Hospital Cost Only(5)</td>
<td>110.8 -0.25 -443.3 Open</td>
<td>-159.3 +2.75 -57.9 Lap</td>
</tr>
<tr>
<td>2. Total Cost</td>
<td>-115.6 -0.25 +462.4 —</td>
<td>-91.7 +2.75 -33.3 Lap</td>
</tr>
<tr>
<td><strong>Variation in Utilities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. 6 Months</td>
<td>-115.6 +0.42 -275.2 Lith</td>
<td>-91.7 +1.3 -70.5 Lap</td>
</tr>
<tr>
<td>4. Upper</td>
<td>-115.6 -3.6 +32.1 —</td>
<td>-91.7 +3.1 -29.6 Lap</td>
</tr>
<tr>
<td>5. Ex ante</td>
<td>-115.6 +1.66 -69.6 Lith</td>
<td>-91.7 +3.4 -27.0 Lap</td>
</tr>
<tr>
<td><strong>Variation in Base Lithotripsy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Stone Recurrence</td>
<td>-88.7 -1.8 +49.3 —</td>
<td>-118.6 +4.2 -28.2 Lap</td>
</tr>
<tr>
<td>7. Urso</td>
<td>-115.6 +3.8 -30.4 Lith</td>
<td>-91.7 -1.42 +64.6 —</td>
</tr>
<tr>
<td>8. Urso; no capital cost</td>
<td>-320.0 +3.8 -84.2 Lith</td>
<td>+112.7 -1.42 -79.4 Lith</td>
</tr>
</tbody>
</table>
Marginal costs and benefits of lithotripsy less open cholecystectomy
Marginal costs and benefits of laparoscopic cholecystectomy less lithotripsy
Difference in cost per 100 patients treated (from Table 5).
Difference in Healthy Year Equivalents [HYE-s] per 100 patients treated. HYE-s are obtained by dividing HME-s in Table 3 by 12. Note: Table 3 measures the loss of HME-s following a procedure. In marginal calculations the benefit of each procedure is the avoidance of the loss associated with the alternative.
Hospital costs are adjusted hospital costs.

HYE-s per hundred patients increases from 0.25 (row 2) to 1.8 (row 6). While these results are subject to significant error they suggest that even a substantial stone recurrence rate is unlikely to be a quantitatively decisive issue if subsequent treatment rates are low and future values are discounted.

Two types of bile salt are available, chenodeoxycholic and ursodeoxycholic acid. The latter is not permitted in Australia at present despite the evidence that it is associated with less diarrhoea and nausea. In row (7) the consequences of its use are examined. Because of the inevitable inaccuracy which would result from attempting to cost urso when it is not presently available we have not altered the total cost estimate. It is assumed that persons with pain plus other symptoms will still experience pain but that the other symptoms cease. The consequence of this is a significant reduction in lost HME-s from a base of 1.49 (Table 3) to 1.0 per patient. This would result in the unambiguous superiority of lithotripsy over open cholecystectomy. Laparoscopic cholecystectomy would remain the cheaper procedure but lithotripsy would result in less loss of HME-s - 1.17 per patient for laparoscopic cholecystectomy as compared to 1.0 per patient for lithotripsy. Converting to HYE-s this implied a difference of 1.42 HYE per 100 patients.

Row (8) combines the previous result with the additional assumption that there is no capital cost associated with lithotripsy. This scenario would correspond to a situation in which machines dedicated to biliary lithotripsy had been replaced by multi purpose machines that were independently justified through other treatments. If such machines had excess capacity then the policy issue would be the use of this free capacity to treat gallstones. Results in row (8) reflect the very significant cost of the machine in the hospital cost of lithotripsy (46 percent) or in the total cost (40 percent). If this is eliminated, lithotripsy is the unambiguously cheapest option. In combination with the use of ursodeoxycholic acid it would also have the least impact upon the quality of life.

In summary:

- The superiority of laparoscopic cholecystectomy is robust to most of the values assumed in the analysis. Its outcome is superior in terms of HYE unless subsequent evidence indicates a very high incidence of common bile duct damage. It is also the cheapest procedure both in terms of direct hospital costs and total costs.

- Open cholecystectomy is unambiguously inferior to laparoscopic cholecystectomy as the procedure of first choice. It is a more expensive option than lithotripsy.

- Lithotripsy has the highest direct costs because of three factors; the large capital cost, the cost of bile salts and the number of repeated treatments required. Because of lower indirect costs it is cheaper from a societal perspective than open cholecystectomy. The
side effects of the bile salt therapy result in a poorer outcome, as measured by HYE-s, but the difference from open cholecystectomy is probably insignificant.

- Lithotripsy could, potentially, be the first choice procedure under certain circumstances: (1) the patient is suitable for lithotripsy treatment, (2) the use of ursodeoxycholic bile salts if these prove, in the event, to have no side effects, (3) the use of the excess capacity of an independently justified lithotriptor, and (4) when patients exhibit a very strong preference for a non-invasive procedure.
6. DISCUSSION

The evaluation reported in this paper encountered a number of methodological problems, some of which were unique to the evaluation but others of a more general nature. The theory of economic evaluation commences with the assumption that the clinical consequences of an intervention are understood. In practice, this is unlikely to be true in the case of a new technology and there is likely to be a constant trade-off between the timeliness of an evaluation with respect to policy relevance and the availability of reliable information on clinical outcomes. This was particularly true in the present case. Estimates of long term stone recurrence and treatment after lithotripsy, the incidence of post-cholecystectomy syndrome and the complications associated with laparoscopic cholecystectomy are all uncertain. However, the most serious deficiency is the quality of the information on the patients' experience. This deficiency is particularly serious because of the divergence between clinical and patient experience and as noted, the present study has been forced to adopt estimates based upon very imperfect data.

Temporary and Permanent Health States

The study highlights a number of unresolved methodological issues in the cost utility literature. The first of these is associated with the conversion of temporary morbid states in HYE-s. The approach adopted here has been to measure the temporary states against the worst temporary state and then to scale them according to the value of the worst state when it is treated as a chronic condition until death. There are two potential weaknesses with the procedure. First, if Torrance's (1986) rule was followed the chronic, morbid condition would be followed by death after a period of time equal to a period of temporary morbidity. In our case the chronic condition would be followed by death only after 12 weeks (the nominated period of temporary morbidity for the interview). The rating of such an option would be so distorted by the imminence of death that it is unlikely that answers would bear any relation to the utility of the health state revealed in another context.

The pragmatic solution adopted with this first problem was to measure the chronic health state for two periods - twelve months and twelve years before death. As discussed, the results obtained from both periods were not significantly different when measured with either the rating scale or time trade off technique. While this does not rule out the possibility of similar errors in both observations the results are encouraging. The prior expectation was that the shorter period might still be distorted by the close proximity of death and this would bias the results upwards. Measurement from the longer period might be contaminated by "saturation" or "adaptation". Casual observation of respondents suggested the possibility of the former - that life in the worst health state "would be unendurable for that long". This would bias answers downwards. In fact no significant discrepancy between the results was observed.

The validity of the temporary health state utilities is also confounded by the assumption that the transformation to a zero-one scale does not distort peoples true preferences. There is ample evidence that preferences are not always constant under linear transformation but in the absence of an independent gold standard, the assumption cannot be tested in the present context. Alternative approaches to the conversion of temporary states probably have even less validity (see for example Nord, 1992).
Ex Ante and Ex Post Measurement

The second methodological issue arises from the measurement of the disutility of the anticipated operation and the associated risk of death. Our approach was to provide respondents with a summary of the information patients would receive prior to the operation and to quantify the disutility by trading-off the operation against weeks in the worst temporary health state. The approach incorporates a different basis for measurement from the other scenarios and the difference highlights two perspectives on CUA that, in principle, are fundamentally different. The first and conventional approach is an attempt to adjust the actual consequences of an intervention for the utility associated with the quality of life experienced. This *ex post* approach follows what Robinson (1986) described as the material welfare tradition in economics and which Culyer (1992) more recently describes as "extra welfarism". The object of measurement is what will actually be experienced not what is anticipated. By contrast, most welfare economics is based upon the libertarian premise that revealed preferences are the gold standard for measurement. In the present context this implies that people's expectations and attitudes to risk are relevant as they will affect their revealed preferences even if these factors are largely unrelated to *ex post* experiences. With this tradition ("The new welfare economics" in conventional terminology; welfarism in Culyer) it is the anticipated and not the realised health state that is the central concern. The issue is not trivial. Our initial qualitative research indicated that a percentage of the population feel very strongly about undergoing an operation.

Measuring Health States with Imperfect Data

The final methodological issue arose because of the very imperfect correspondence between clinical outcome and patient experience. In a textbook CUA, patient quality of life would be largely determined by clinical condition and HYE-s calculated from the clinical evidence on the likelihood and duration of different health states and from an evaluation of the utility of these health states. In cases where the patient experience is highly variable in relation to the clinical condition and also variable through time there are several options. The first is to undertake a very extensive qualitative enquiry which attempts to encompass all of the main health states encountered at different points in time: in effect a parallel study to the clinical evaluation. This would imply a correspondingly large number of interviews to convert scenarios into utility values. While conceivable, it is unlikely that such a research strategy would be cost effective in relation to the value of the final results. A second option and the one adopted and described here is to truncate the qualitative enquiry and utility interviews by classifying patients on the basis of a number of important aspects of the health state into a smaller number of groups and imposing average utility values for an average period of time and testing results with sensitivity analysis. While this may be the only strategy consistent with a limited research budget it necessarily casts doubt upon the sensitivity of the scenarios and the reliability of the implicit "trial". It may also result in an indecisive outcome when sensitivity analysis reverses the initial conclusion.

The final option and, in our view the gold standard for such research, is to gather quality of life data in tandem with a randomised control trial or longitudinal clinical trial. This could, in principle, form the basis for the construction of multiple scenarios as described in the first option. The more cost effective strategy would be to collect individual quality of life data that were compatible with - an input into - a validated multi attribute utility scale. As noted in the introduction none of the existing MAU scales are sensitive to the QoL factors associated with gallstone disease. More importantly there is serious doubt about their validity in relation to the objective of resource allocation (Nord et al 1992). This dilemma highlights the need for the development of such a scale.


St Vincent's Hospital, Biliary Lithotripsy Evaluation Subcommittee, (1992), *Biliary Lithotripsy Assessment Program, Second Interim Report*, St Vincent's Hospital, Melbourne.


## APPENDIX 1

### Survey of Clinical Literature

<table>
<thead>
<tr>
<th>Complication</th>
<th>Open Cholecystectomy</th>
<th>Laparoscopic Cholecystectomy</th>
<th>ESWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death (from a variety of causes)</td>
<td>0.1 - 0.2%</td>
<td>Worldwide</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.12 - 0.22%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>St Vincent's 0.1 - 0.2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Worldwide</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.01%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>St Vincent's 0.22%</td>
<td></td>
</tr>
<tr>
<td>Conversion to open Cholecystectomy (depends on selection criteria)</td>
<td>Not Applicable</td>
<td>Worldwide 10 - 15%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>St Vincent's 5%</td>
<td></td>
</tr>
<tr>
<td>Subsequent Cholecystectomy (due to a variety of causes)</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>St Vincent's 20.0%</td>
<td></td>
</tr>
<tr>
<td>CBD damage</td>
<td>Worldwide 0.2 - 0.4</td>
<td>0.2 - 3.0%</td>
<td></td>
</tr>
<tr>
<td>Laceration</td>
<td>0.05 - 0.2</td>
<td>St Vincent's 0.2%</td>
<td></td>
</tr>
<tr>
<td>Transection</td>
<td>0.1 - 0.2</td>
<td>St Vincent's 0.2%</td>
<td></td>
</tr>
<tr>
<td>Hernia</td>
<td>5%</td>
<td>Not Known</td>
<td></td>
</tr>
<tr>
<td>Retained stone requiring ERCP Sphincterotomy (depends on use of Operative Cholangiography)</td>
<td>1-5% St Vincent's 1%</td>
<td>1-5% St Vincent's 1%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-2% St Vincent's 4/454 as 0.9%</td>
<td></td>
</tr>
<tr>
<td>Recurrence of stones</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Worldwide 10% per year for first 5 years with few further recurrences after 5 years for bile salt therapy alone St Vincent's</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approximately as above</td>
<td></td>
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### APPENDIX 2: PROBABILITIES USED IN THE OUTCOME TREE

<table>
<thead>
<tr>
<th>TIME (Months)</th>
<th>HSe</th>
<th>HS1</th>
<th>HS2</th>
<th>HS3</th>
<th>HS4</th>
<th>HS5</th>
<th>HS6</th>
<th>HS7</th>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Severe Post Operative Symptom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Normal Post Operative Cholecystectomy</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Post Operative Discomfort</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strong Pain/Severe Diarrhoea/ Nausea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Severe Pain</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Severe Diarrhoea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moderate Pain/ Severe Diarrhoea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moderate to Mild Pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laparoscopic Cholecystectomy</td>
<td>.246</td>
<td>.323</td>
<td>.108</td>
<td>.02</td>
<td>.431</td>
<td>.292</td>
<td>.29</td>
<td></td>
</tr>
<tr>
<td>0 - .5</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>.5 - 6.5</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>6.5 - 18'</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Open Cholecystectomy</td>
<td>.35</td>
<td>.467</td>
<td>.183</td>
<td>.115</td>
<td>.04</td>
<td>.524</td>
<td>.30</td>
<td></td>
</tr>
<tr>
<td>0 - 1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 7</td>
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<tr>
<td>7 - 18'</td>
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</tr>
<tr>
<td>Lithotripsy</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 - 2</td>
<td></td>
<td></td>
<td></td>
<td>.168</td>
<td>.130</td>
<td>.073</td>
<td>.100</td>
<td>.302</td>
</tr>
<tr>
<td>2 - 6</td>
<td></td>
<td></td>
<td></td>
<td>.080</td>
<td>.123</td>
<td>.073</td>
<td>.038</td>
<td>.322</td>
</tr>
<tr>
<td>6 - 18'</td>
<td></td>
<td></td>
<td></td>
<td>.02</td>
<td>.04</td>
<td></td>
<td></td>
<td>.30</td>
</tr>
</tbody>
</table>

Source: Patient Survey

**Note:**

Probabilities for the final period were obtained from the patients’ reported symptoms, attributable to the procedure, in the month prior to the survey. The time period since the procedure was calculated from the protocol data. Probabilities were to be estimated as the number reporting symptoms as a proportion of the total respondents who had the procedure 6-18 months earlier. While there were 86 laparoscopic cholecystectomy patients in this category few patients had received either of the other two procedures in this period. Consequently probabilities for the post lithotripsy health states were based upon the experience of the 199 patients who had the procedure 12-24 months earlier and for open cholecystectomy upon the 76 patients undergoing the operation 18-30 months earlier. In principle, the use of these groups of patients should have biased the probability of symptoms downwards. In fact, the proportion reporting mild to moderate pain after laparoscopic cholecystectomy in the months prior to the survey remained the same (29.2%) as for the period 2 weeks to 6 months after the procedure. The proportion of lithotripsy patients who reported mild to moderate symptoms in period 3 actually rose (to 39.5%). As the latter pattern is unreasonable the probability of mild to moderate pain was set equal to the probability in the previous period (0.30). For open cholecystectomy the lower percentage reporting moderate to mild pain (12.6%) was likely to be biased downwards relative to the estimates for the other two procedures. Consequently the probability of continuing severe pain and of moderate to mild pain for open cholecystectomy was set equal to the probability in the case of lithotripsy patients. The assumption is consistent with the result from the Sheffield random control trial that after 6 months there was no significant difference in episodes of pain between the two procedures. A very similar proportion reported pain amongst the 144 patients receiving lithotripsy treatment 25-33 months before the survey. This suggests a very long period during which symptoms are retained. This is presumably attributable to post cholecystectomy syndrome.
APPENDIX 3: OUTCOME TREES AND PROBABILITIES

A1: LITHOTRIPSY (CLINICAL PERSPECTIVE)

- Treatment
  - Stone Clearance 1st, Subsequent Treatment
    - Recurrence
      - Syndrome
        - Full Health
    - No Stone Clearance
      - Treatment
        - Asymptomatic
      - Complications
        - Death
  - No Stone Clearance
    - Asymptomatic

Probabilities: See Appendix 1
A2: LITHOTRIPSY (PATIENT PERSPECTIVE)

No Initial Symptoms
- No Recurrence
  - Treatment
  - Stone Recurrence
    - Asymptomatic
- Stone Recurrence
  - Laparoscopic Cholecystectomy//Open Cholecystectomy
    - Health
    - Syndrome
    - Treatment
    - Asymptomatic

Severe Pain, Diarrhoea, Nausea
- Severe Pain
- Severe Diarrhoea
- Moderate Pain, Severe Diarrhoea
- Moderate Pain

Stones in CBD - See A3
- Death

Probabilities, Time Periods: See Appendix 1 and 2
A3: STONES IN CBD FOLLOWING TREATMENT

Stones in CBC
P = 0.01 - 0.02

Open Procedure
P = 0.05

ERCP
Sphincterotomy
P = 0.95

Successful Removal
P = 0.89

Death
P = 0.01

Morbidity*
P = 0.10

See B1

* haemorrhaging self-limiting or may require open procedure
* perforated duodenum - requires open procedure
* pancreatitis can only treat complications - if severe can result in death
* cholangitis
* jaundice
B1: OPEN CHOLESCYSTECTOMY

Procedure
- Post Operative Mild/Moderate Pain
  - Normal Health
  - Post Operative Strong Pain
    - Mild to Moderate Pain
      - Severe Pain
      - Normal Health
      - Syndrome
    - Normal Health
  - Post Operative Discomfort
    - CBD Damage - See D1
  - Complications
    - Stones in CBD - See A3
  - Death

Probabilities, Time Periods: See Appendix 1 and 2
C1: LAPAROSCOPIC CHOLECYSTECTOMY

Post Operative Discomfort
  - Normal Health
  - Mild/Moderate Pain
    - Normal Health
    - Severe Pain
  - Syndrome

Post Operative Strong Pain

Post Operative Moderate to Mild Pain

Conversion to Open Cholecystectomy
  - CBD Damage - See D1
  - Stones in CBD - See A3

Complications

Procedure

Death

Probabilities, Time Periods: See Appendix 1 and 2
D1: COMMON BILE DUCT DAMAGE:
OUTCOME PROBABILITIES: OPEN AND LAPAROSCOPIC
CHOLECYSTECTOMY

CBD Damage
Open Cholecystectomy P = 0.002-0.004

CBD Damage
Laparoscopic Cholecystectomy P = 0.002-0.03

Laceration
P = 0.5-0.75

Death
P = 0.001

Successful Repair
P = 0.80

Transection
P = 0.25-0.5

Stricture(s)
P = 0.099

Death
P = 0.01-0.02

Permanent Damage
P = 0.30-0.20

Liver Failure
Very low

Liver Transplant
Very low

Successful Repair
P = 0.60

Death
P = 0.10-0.20

Permanent Damage
P = 0.099

Liver Failure
Very low

Liver Transplant
Very low
### Appendix 4: Health State Scenarios

<table>
<thead>
<tr>
<th>Health State</th>
<th>Category</th>
<th>Scenario</th>
</tr>
</thead>
</table>
| 1            | Open Cholecystectomy (normal) | You have had a successful operation.  
You get tired very easily and you don't sleep very well at night.  
The wound gives you a continuous dull sort of pain.  
You find that you cannot carry out most of your normal activities. |
| 2            | Laparoscopic Cholecystectomy (normal) | You have had a successful operation.  
You feel a little tired.  
It is uncomfortable for you to move.  
You cannot exercise or lift heavy things.  
You find that you can do most of your normal activities. |
| 3            | Severe pain  
Severe diarrhoea  
Nausea | You are having specialist medical treatment.  
Your treatment gives you 2 or 3 attacks of continuous agonising pain in your chest and back.  
The pain can last from half an hour to 4 hours. You can do nothing to relieve the pain.  
When the pain goes you can return to your normal activities.  
The treatment also gives you uncontrollable diarrhoea 2 or 3 times a week. You need to be near a toilet most of the time. About once a week the diarrhoea is very painful.  
About once a week you feel a bit nauseous for a few hours. |
| 4            | Severe pain (periodically) | You are having specialist medical treatment.  
Your treatment gives you 2 or 3 attacks of continuous agonising pain in your chest and back.  
The pain can last from half an hour to 4 hours. You can do nothing to relieve the pain.  
When the pain goes you can return to your normal activities. |
| 5            | Severe diarrhoea | You are having specialist medical treatment.  
You have uncontrollable diarrhoea 2 or 3 times a week.  
You need to be near a toilet most of the time.  
About once a week the diarrhoea is very painful. |
| 6            | Moderate pain  
Severe diarrhoea | You are having specialist medical treatment.  
The treatment gives you an uncomfortable heavy feeling in your stomach most of the time.  
About once a month you also have a cramping pain in your chest and back.  
You have uncontrollable diarrhoea 2 or 3 times a week.  
You need to be near a toilet most of the time.  
About once a week the diarrhoea is very painful. |
| 7            | Moderate pain | You are having specialist medical treatment.  
The treatment gives you an uncomfortable heavy feeling in your stomach most of the time.  
About once a month you also have a cramping pain in your chest and back. |
| 8            | Operation 1 | You will have an operation.  
Your doctor has told you that there is a very small risk of dying (about one person in every 1,000 dies).  
After the operation you will return to full health straight away. |
| 9            | Operation 2 | You will have an operation.  
Your doctor has told you that there is a very small risk of dying (about one person in every 1,000 dies).  
After the operation you will be in hospital for one week and you will:  
- have a dull gnawing sort of pain all of the time;  
- feel sick and want to vomit most of the time;  
- find coughing and moving painful;  
- have constipation and will be given an enema;  
- have trouble sleeping. |
APPENDIX 5: CALCULATION OF LITHOTRIPSY COSTS AND HME-S WITH RECURRENCE AND URSO

The best information implies a recurrence rate of 50% and that 18% of asymptomatic stones will result in treatment over a 15 year period. Hence the 50% of failures will lead to 9% more treatments. It is assumed that:

- The 9% receiving subsequent treatment are distributed over the 15 years, ie 0.6% or (.006) per annum for 15 years.
- Patients are asymptomatic until 12 months before treatment.
- QoL in the 12 months is equal to HS4 (severe pain periodically; Utility = 0.87).
- Treatment is by laparoscopic cholecystectomy.
- There are average treatment costs for the subsequent laparoscopic cholecystectomy.
- Costs and benefits are discounted at 5%.

**Costs**

Total cost per person = initial litho cost + discounted lap chol cost

\[= 5033 + (.006) (4116) (10.90) \]

\[= $5302 \]

**HME**

- The additional loss when recurrence occurs:

  \[= \text{pre-treatment loss} + \text{loss from lap chol} \times \text{average discount factor} \]

  \[= [(12m)(.13) + 1.17] (10.9/15) \]

  \[= 1.98 \]

- Average loss with 9% recurrence:

  \[= 1.49 + .09 (1.98) \]

  \[= 1.67 \]

**Urso**

HMEs for lithotripsy were recalculated assuming no diarrhoea or nausea, ie, HS3 and HS6 become equal in value to HS4 and HS7 respectively. The utility of HS5 is set equal to 1.0. The resulting loss of HMEs associated with lithotripsy in the base case is 0.971 from the QoL plus 0.03 from death, ie a total loss of 1.01 HMEs.

- 10.9 is the present value of one HME per annum for 15 years discounted at 5%, ie:

  \[10.9 = 1 + d + d^2 + \ldots + d^{14}, \text{ where } d \text{ is the discount factor } 1/1.05]
APPENDIX 6: SELECTION CRITERIA FOR LITHOTRIPSY AND LAPAROSCOPIC CHOLECYSTECTOMY PATIENTS INTO THE ST VINCENT'S TRIAL

LITHOTRIPSY

Inclusion Criteria

- Patients must be suffering from symptomatic gallstones.
- The gall bladder must be functioning.
- There must be no more than three stones.
- The stones must not be heavily calcified.
- No stone must be greater than 3 cm in diameter or less than 5-6 mm in diameter.
- The volume of multiple stones must not exceed that of a 3 cm single stone.

Exclusion Criteria

- Pregnancy (all female patients within the child bearing age group must be tested for pregnancy).
- Jaundice.
- The presence of acute cholecystitis, acute pancreatitis or acute cholangitis.
- Stones that are too big, too small or too numerous.
- A non-functioning gall bladder.
- The presence of a pacemaker.
- Cysts or aneurisms which would be in the path of the shockwave during ESWL.

LAPAROSCOPIC CHOLECYSTECTOMY

- The majority of patients with symptomatic gallstones are suitable for laparoscopic (percutaneous) cholecystectomy.
- Relative contra-indications include previous upper abdominal surgery and acute cholecystitis.
- Absolute contra-indications include jaundice, a bleeding tendency and cirrhosis of the liver with portal hypertension.
- Pregnancy is usually regarded as a contra-indication to laparoscopic cholecystectomy. Certainly the enlarged uterus in pregnancy may be damaged by the Verres needle or by the trocars.
- Jaundiced patients may have the obstructing stone(s) removed by ERCP sphincterotomy and after recovering from this, may have the gall bladder removed by laparoscopic (percutaneous) cholecystectomy.