An Economic Evaluation of Laparoscopic Cholecystectomy for Public Hospitals in Trinidad and Tobago
HH Bailey,1 DV Dan2

ABSTRACT

Laparoscopic Cholecystectomy (LC) is compared to the Open and Minilap approaches in a Cost Minimization Analysis for public hospitals in Trinidad and Tobago. The analysis shows that despite the high initial equipment cost required to perform LC, substantial savings can be achieved at the hospital level by converting from a minilap or open regime to a laparoscopic regime for cholecystectomy. Because of the reduced recovery period for the patient, LC represents further savings to other sectors of the economy as patients return to work much earlier after LC than after the other two approaches.

INTRODUCTION

The first Laparoscopic Cholecystectomy (LC) to be performed in the English Speaking Caribbean took place at a private hospital in Trinidad and Tobago in 1991 (1). To date LC is performed in public hospitals in at least six Caribbean islands but not in Trinidad and Tobago. A recent survey revealed that LC is perceived to be a higher cost procedure than other approaches to cholecystectomy (2).

The benefits to the patient of having cholecystectomy performed laparoscopically have been well documented (3 – 5) and laparoscopy is arguably the future of many commonly performed general surgery procedures (6). Despite this, even in the private sector, LC has not been widely adopted in Trinidad and Tobago. By 2002, a mere 4% of total (public plus private) cholecystectomies in Trinidad and Tobago were performed laparoscopically (2). The two main treatment alternatives for uncomplicated gall bladder disease are minilap and open cholecystectomy (MC, OC).

The high initial cost of equipment required to perform LC suggests that this approach to cholecystectomy will represent an increase in cost to the hospital. Some early studies in other countries support this hypothesis (7) while others refute it (8, 9) but no analysis has been published for Trinidad and Tobago. This study compares the cost to the hospital and to society of a laparoscopic programme versus open and minilap strategies for public hospitals in Trinidad and Tobago.

METHODS

A Cost-Minimization Analysis was undertaken based on a clinical decision model using data from published clinical studies, hospital cost data and local (ie Trinidad) clinical practice. Elaborating on an early model (10), this analysis compares Laparoscopic Cholecystectomy (LC) with Minilaparotomy Cholecystectomy (MC) and Open Cholecystectomy (OC) in terms of costs to the hospital and to society in the form of lost output during convalescence. The...
health outcomes of the three strategies were considered to be equivalent. The model is displayed in the Figure.

Laparoscopic Approach

- If CBD stones are found (P1 = 0.093), Laparoscopic cholecystectomy with IOC (C1) is performed (P3 = 0.4). If CBD stones are not flushed into the duodenum (P3 = 0.4) then the cholecystectomy can proceed. If the CBD stones are large or if they cannot be flushed it is assumed that an open cholecystectomy with CBD exploration (C2) is performed (P4 = 0.6). Laparoscopic CBD exploration requires special equipment including a cholecostoscope, fluoroscopy and laparoscopic dilators. This option is excluded for the purposes of this study. Similarly, Endoscopic Retrograde Cholangio-Pancreatography (ERCP) is not available at public hospitals in Trinidad and Tobago.

The C3 arm consists of patients with a clear CBD. These patients undergo a basic LC which has a conversion rate to open (C4) of 4.8% (P5 = 0.952 and P6 = 0.048) (11). Reasons for conversion include difficult anatomy, intra-operative bleeding from CBD injury (12) with a range varying from 2.9% to 6.9% (13) depending on the series used and the how recent the study is.

Mini-lap Approach

Following the minilap branch of the Figure, the first decision involves patient suitability. Morbid obesity, previous upper abdominal surgery and acute cholecystitis are considered to be at least relative contra-indications (14). Obesity is known to be a predisposing factor for cholelithiasis (15). Delays in diagnosis (16) together with long waiting lists for elective surgery further increase the theoretical risk of multiple attacks by the time the patient presents for surgery. Quantifying the number of patients in this category in Trinidad and Tobago is impossible given the available data. In the Figure, it is assumed that 30% of patients at the outset will be unsuitable for the minlap approach (P7 = 0.7, P8 = 0.3).

For suitable patients without CBD stones a basic mini-lap cholecystectomy is performed (C7). A conversion rate to open cholecystectomy of 22% (C8) is used (17). Patients unsuitable for the mini-lap approach undergo an OC with or without CBD exploration depending on the presence of CBD stones (C9 and C10).

Open Approach

If there is a pre-operative diagnosis of CBD stones, an OC with IOC is performed (C11). As in the laparoscopic and laparoscopic approaches, the probability of success is set at 40% (P3 = 0.4 and P4 = 0.6). Unsuccessful patients undergo OC with CBD exploration (C6).

For suitable patients without CBD stones a basic mini-lap cholecystectomy is performed (C7). A conversion rate to open cholecystectomy of 22% (C8) is used (17). Patients unsuitable for the mini-lap approach undergo an OC with or without CBD exploration depending on the presence of CBD stones (C9 and C10).

Costs

This decision model gives rise to 13 end points (C1 through C13), each of which have different cost profiles. Table 1 shows the cost levels associated with each end-point. The
Laparoscopic Cholecystectomy

The cost associated with each end point comprises hospital costs and costs to society in terms of lost output while the patient is on sick-leave. Only relevant costs are included in this analysis; these are the costs that differ among the various treatment strategies. The hospital costs comprise the following components:

- Operating cost is the cost of the surgery. The cost of operating theatre time is set at TT$1 000 per hour. The operating cost for each pathway is calculated by multiplying the number of minutes for the procedure by TT$16.67 per minute ($1000 per hour).
- Hospital stay: the cost of hospital stay is calculated as TT$800 multiplied by the number of days of stay for each end-point.
- Equipment cost per patient: the cost of the laparoscopic tower from one supplier is quoted as US$28 000. Cheaper equipment is available (from less known brands) and refurbished equipment is available at half of this price. The cost of the laparoscopic instrument set is given as US$8000. It is assumed that the equipment and instruments will have a useful life of 5 years, and are financed by a US$36 000, 5-year 8% government bond. This gives a total cost per year of TT$55 184. Hospital throughput is set at 96 cases per year giving an equipment cost of TT$575 per patient.
- The cost to society in terms of lost output is calculated by multiplying the average earnings per day by the number of sick leave days for each treatment modality. Earnings data in Table 1 were obtained from the National Accounts Division of the Central Statistical Office of Trinidad and Tobago. Total wages and salaries divided by the number of workers for the year 2000 give an average of TT$45 956 per year = TT$126 per day. Earnings data from official sources are known to be understated (18) so any bias introduced here will be in favour of MC and OC which involve longer periods of sick leave.

Details of the costs incurred in each pathway

Studies dealing with early experience typically show two to four days of hospital stay for LC (9,10) however LC is now routinely performed as ambulatory surgery with hospital stay of less than one day (19, 20). It is assumed that LC would be
introduced as ambulatory surgery. Hospital stay is therefore set at 1 day for LC, two days for the minilap approach and four days for the open approach. Sick leave periods were set at 10 days for all of the laparoscopic and minilap procedures (21) and 42 days for all open procedures.

C1: This is a LC with intra-operative cholangiogram (IOC). An operating time of 87 minutes is used based on the mean time for LC in one large study plus an estimate of 30 minutes for IOC (11).

C2, C6, C9 and C12 are open choledocholithotomies. The mean operating time for this procedure is set at 214 minutes (3½ hours) (10).

C3 is a straight LC. An operating time of 57 minutes and hospital stay of one day are set (9,10,11).

C4 is a LC converted to OC. A study of complicated and converted cases found the mean operating time to be 99.4 minutes (11).

C5 and C11 are OC with IOC. It is assumed that MC is not attempted where CBDS are present. The operating time for this procedure is set at 40 minutes plus an additional 30 minutes for IOC.

C7 is a straight MC. One Trinidad study shows a mean of 35 minutes(21). This is the figure used in the analysis.

C8 is MC converted to OC. An operating time of 58 minutes is set. One large MC series (17) included 100 patients with a mean operating time of 40 minutes (total: 4000 minutes). The conversion rate was 22%, so if 78 cases took 35 minutes (=2730 minutes) then the remaining 22 would have taken 57.7 minutes (4000 – 2730 = 1270 minutes, 1270/22 = 57.7). C10 and C13 are straight OC. Operating time is set at 40 minutes.

The cost end-points in Table 1 can now be multiplied by the respective probabilities to provide the expected values of the relevant costs of each treatment modality. In Table 2,

<table>
<thead>
<tr>
<th>Table 2: Hospital costs associated with LC, MC and OC</th>
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<table>
<thead>
<tr>
<th>Hospital Cost</th>
<th>Lost Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laparoscopic approach</td>
<td>$(C1 \times P3 \times P1) + (C2 \times P4 \times P1) + (C3 \times P5 \times P2) + (C4 \times P6 \times P2) = \text{TT } $2759</td>
</tr>
<tr>
<td>Minilap approach</td>
<td>$(C5 \times P3 \times P1 \times P7) + (C6 \times P4 \times P1 \times P7) + (C7 \times P9 \times P2 \times P7) + (C8 \times P10 \times P2 \times P7) + (C9 \times P1 \times P8) + (C10 \times P2 \times P8) = \text{TT } $3282</td>
</tr>
<tr>
<td>Open approach</td>
<td>$(C11 \times P3 \times P1) + (C12 \times P4 \times P1) + (C13 \times P2) = \text{TT } $4047</td>
</tr>
</tbody>
</table>

This is done for hospital costs and Table 3 shows the output lost with each modality. Thus the hospital cost associated with the adoption of LC is given by the expected value of cost end points C1 through C4 in the Figure, ie $(C1 \times P3 \times P1) + (C2 \times P4 \times P1) + (C3 \times P5 \times P2) + (C4 \times P6 \times P2)$.

<table>
<thead>
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</tr>
<tr>
<td>Minilap approach</td>
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| DISCUSSION                                       |

Table 2 shows that costs to the hospital are lower for the laparoscopic approach than for the other two approaches. This is because the reduced hospital stay overcompensates for the equipment cost per patient. In terms of lost output, the laparoscopic approach saves resources over both the MC and OC regimes. The output losses and hospital costs for the three treatment strategies are brought together in Table 4 to...
show the respective total costs to society. Table 5 shows the savings that can be achieved by replacing an MC or OC regime with LC. The potential savings exceed TT$600k per year to the public health sector, and TT$1.4M per year to the economy if an LC programme replaces an OC programme.

Table 5: Savings associated with LC at various levels of throughput

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<th>1 Patient</th>
<th>Laparoscopic approach savings</th>
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<tbody>
<tr>
<td></td>
<td>Hospital costs</td>
<td>Lost output</td>
<td>Total</td>
</tr>
<tr>
<td>Lap vs minilap approach</td>
<td>$524</td>
<td>$1635</td>
<td>$2158</td>
</tr>
<tr>
<td>Lap vs open approach</td>
<td>$1289</td>
<td>$3631</td>
<td>$4920</td>
</tr>
<tr>
<td>96 Pts – 1 year hospital throughput</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Lap vs minilap approach</td>
<td>$50 278</td>
<td>$156 935</td>
<td>$207 213</td>
</tr>
<tr>
<td>Lap vs open approach</td>
<td>$123 711</td>
<td>$348 622</td>
<td>$472 333</td>
</tr>
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<td>288 Pts – 1 year national throughput</td>
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<td></td>
<td></td>
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<tr>
<td>Lap vs minilap approach</td>
<td>$150 834</td>
<td>$470 806</td>
<td>$621 640</td>
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<tr>
<td>Lap vs open approach</td>
<td>$371 134</td>
<td>$1 045 865</td>
<td>$1 417 000</td>
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</table>

Under certain conditions, MC is lower in cost than LC. Thus, the lowest cost end-point in the Figure and Table 1 is C7 (straight MC). However, comparing operative regimes, a laparoscopic programme represents cost savings over both MC and OC programmes.

Concerning complications associated with the three approaches to cholecystectomy, early clinical comparisons of LC and OC identified certain complications associated with the former including higher rates of CBD injury (22, 23). A wide literature suggests that LC is associated with lower morbidity and mortality than OC and attributes the higher rates of CBD injury observed in early reviews to widespread inexperience among surgeons when the procedure was first introduced (13). Prospective randomized single-blind studies comparing LC with MC found no difference in post-operative complication and mortality rates between these two procedures (24, 25).

In conclusion, LC saves resources to the health system and other sectors when compared with OC and MC. Hospital morbidity and mortality rates are not adversely affected by LC. Further, LC represents the first stage in the transition to advanced laparoscopic surgery (6) therefore LC represents both a savings opportunity and a development opportunity to the public health system.

This paper seeks to evaluate the cost implications of laparoscopic cholecystectomy for public hospitals in Trinidad and Tobago but to achieve these cost savings, management would play a critical role in the introduction of laparoscopic general surgery services in public hospitals. A cadre of competent personnel must be developed to support any such initiative. Information systems would also need to be put in place to track the quality of outcomes as well as to monitor variables that will impact on economic outcomes such as operating time and hospital.

ACKNOWLEDGMENT
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REFERENCES