An Economic Evaluation of Laparoscopic Cholecystectomy for Public Hospitals in Trinidad and Tobago

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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.

Una Evaluación Económica de la Colecistectomía Laparoscópica para los Hospitales Públicos en Trinidad y Tobago

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RESUMEN

La colecistectomía laparoscópica (CL) es comparado aquí con la cirugía abierta y la mini-laparotomía en un análisis de minimización de costos para los hospitales públicos en Trinidad y Tobago. El análisis muestra que a pesar del alto costo inicial del equipo requerido para realizar la CL, pueden lograrse ahorros sustanciales a nivel de hospital mediante la conversión del régimen de minilaparotomía o el de cirugía abierta a un régimen laparoscópico en la realización de la cole-cistectomía. En virtud de la reducción del periodo de recuperación de los pacientes, la CL representa ahorros ulteriores en otros sectores de la economía, ya que los pacientes regresan a sus trabajos en un espacio de tiempo mucho más corto, en comparación con lo que ocurre con las otras dos vías de acceso.

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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

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health outcomes of the three strategies were considered to be equivalent. The model is displayed in the Figure.

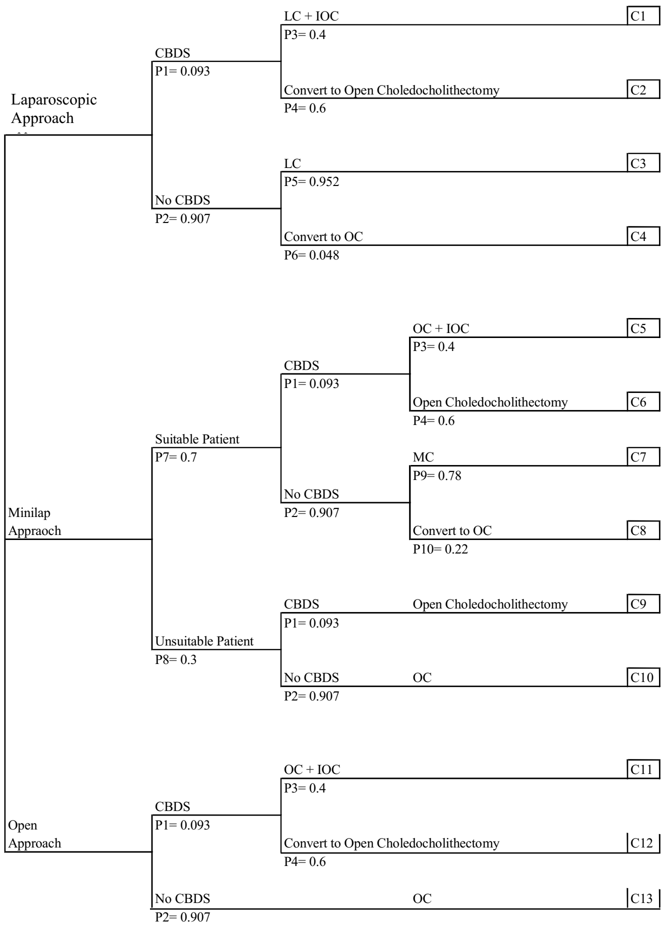

Figure: Decision model for cholecystectomy in Trinidad

Legend

LC	Laparoscopic cholecystectomy
IOC	Intra-operative cholangiogram
CBDS	Common bile duct stones
MC	Mini-laparotomy cholecystectomy
OC	Open cholecystectomy

Pathways and Probabilities

After the decision has been made on the need for a cholecystectomy, a further decision has to be made on the possible presence of common bile duct stones (CBD). This is generally diagnosed pre-operatively with liver function tests and ultrasound evaluation of the biliary tree. The incidence of CBD stones is set at 9.3% (10).

Laparoscopic Approach

For patients with a pre-operative diagnosis of CBD stones (C1 arm), a LC with intra-operative cholangiogram (IOC) is performed. If no stones are found or if small stones are 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 choledochoscope, fluoroscopy and laparoscopic dilators. This option is excluded for the purposes of this study. Similarly, Endoscopic Retrograde Cholangio-Pancreaticography (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).

Of the patients that are suitable for the minlap approach, 9.3% are assumed to have a pre-operative diagnosis of CBD stones (10). These patients undergo OC with IOC (C5). As in the laparoscopic arm of the decision model, the probability that this will be successful 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 minilap 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 minilap and laparoscopic approaches, the probability of success is set at 40% (P3 = 0.4 and P4 = 0.6). For patients with no CBD stones, a basic OC is performed (C13).

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

Table 1: Cost associated with clinical pathways in the Figure

Probabilities	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10			
	0.093	0.907	0.400	0.600	0.952	0.048	0.700	0.300	0.780	0.220			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
Hospital costs													
Operating time (mins)	87	214	57	99	70	214	35	58	214	40	70	214	40
TT$ per minute	16.67	16.67	16.67	16.67	16.67	16.67	16.67	16.67	16.67	16.67	16.67	16.67	16.67
Operating cost	1450	3567	950	1650	1167	3567	583	967	3567	667	1167	3567	667
Hospital stay (days)	1	4	1	4	4	4	2	4	4	4	4	4	4
TT$ per day	800	800	800	800	800	800	800	800	800	800	800	800	800
Cost of hospital stay	800	3200	800	3200	3200	3200	1600	3200	3200	3200	3200	3200	3200
Equipment cost/ Patient	575	575	575	575									
Cost of procedure	2825	7342	2325	5425	4367	6767	2183	4167	6767	3867	4367	6767	3867
Cost to society													
Sick leave (days)	10	42	10	42	42	42	10	42	42	42	42	42	42
Avg earnings/day	126	126	126	126	126	126	126	126	126	126	126	126	126
Lost output	1260	5292	1260	5292	5292	5292	1260	5292	5292	5292	5292	5292	5292
Total cost	**4085**	**12634**	**3585**	**10717**	**9659**	**12059**	**3443**	**9459**	**12059**	**9159**	**9659**	**12059**	**9159**

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 choledocholithectomies. 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 aditional 30 minutes for IOC.

C7 is a straight MC. One Trindad 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, 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 x P3 x P1) + (C2 x P4 x P1) + (C3 x P5 x P2) + (C4 x P6 x P2).

Table 2: Hospital costs associated with LC, MC and OC

Hospital Cost	
Laparoscopic approach	= (C1 x P3 x P1) + (C2 x P4 x P1) + (C3 x P5 x P2) + (C4 x P6 x P2) = TT $2759
Minilap approach	= (C5 x P3 x P1 x P7) + (C6 x P4 x P1 x P7) + (C7 x P9 x P2 x P7) + (C8 x P10 x P2 x P7) + (C9 x P1 x P8) + (C10 x P2 x P8) = TT $3282
Open approach	= (C11 x P3 x P1) + (C12 x P4 x P1) + (C13 x P2) = TT $4047

Table 3: Lost output associated with LC, MC and OC

Lost Output	
Laparoscopic approach	= (C1 x P3 x P1) + (C2 x P4 x P1) + (C3 x P5 x P2) + (C4 x P6 x P2) = (TT $1661)
Minilap approach	= (C5 x P3 x P1 x P7) + (C6 x P4 x P1 x P7) + (C7 x P9 x P2 x P7) + (C8 x P10 x P2 x P7) + (C9 x P1 x P8) + (C10 x P2 x P8) = (TT $3295)
Open approach	= (C11 x P3 x P1) + (C12 x P4 x P1) + (C13 x P2) = (TT $5292)

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

Table 4: Total cost to society for LC, MC and OC

	Hospital Costs	TT Dollars Lost Output	Total	Bed days	Op theatre Minutes	Sick leave days
1 Patient						
Laparoscopic approach	$2759	$1661	$4419	1.30	69	13.2
Minilap approach	$3282	$3295	$6578	3.01	52	26.2
Open approach	$4047	$5292	$9339	4.00	51	42.0
96 pts – 1 year hospital throughput						
Laparoscopic approach	$264 825	$159 410	$424 235	125	6596	1265
Minilap approach	$315 103	$316 345	$631 449	289	5037	2511
Open approach	$388 537	$508 032	$896 569	384	4879	4032
288 pts – 1 year national throughput						
Laparoscopic approach	$794 476	$478 231	$1 272 706	374	19 787	3795
Minilap approach	$945 310	$949 036	$1 894 346	867	15 111	7532
Open approach	$1 165 610	$1 524 096	$2 689 706	1152	14638	12096

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

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

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.

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